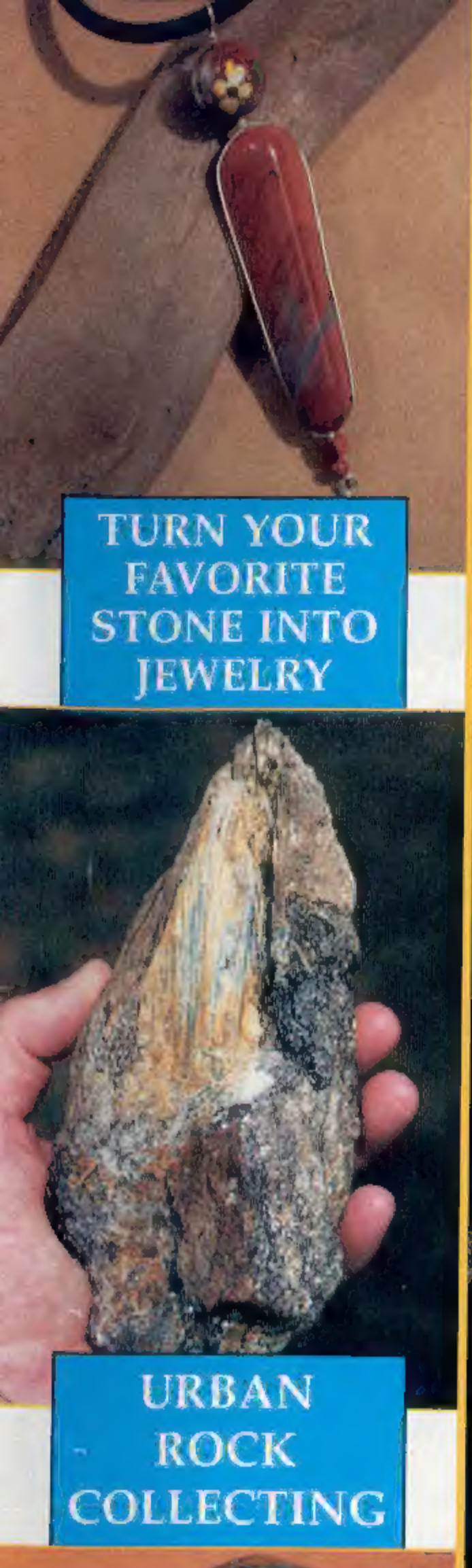

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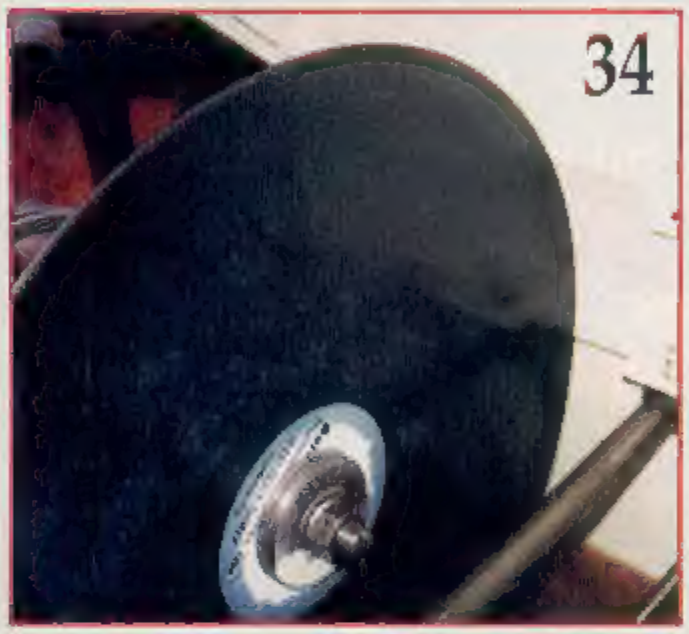

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COVER: A collection of fossils from Wonders of the World, Santa Monica, California: colorful opalized ammonite, a 7-inch trilobite and a saber-toothed cat skull. (Photo by Earl Lewis)

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Exploring the Mineral Wealth of CANADA

These vibrant cinnamon grossular garnets, variety hessonite, are from the Jeffrey Quarry at Asbestos, Quebec. (Photos by the author)

Rockhounding in the Great White North

by Bob Jones

As collectors, we often forget that Canada, the northern portion of our continent, is a great source of minerals. It has produced some wonderfully rare collector minerals, like serandite from Mount St. Hilaire, and lazulite from the Yukon. It is also a great source of industrial minerals like asbestos, nickel and more. For the lapidary, Canada is the type locality for labradorite, and yields tons of fine nephrite jade, bright-blue sodalite, and diamonds from the far north. For the collector of fluorescent minerals, nothing is brighter than the brilliant yellow-responding wernerite, now called meionite, a member of the scapolite group, which is found at several localities north of Montreal.

The gold prospector sometimes forgets the Klondike region is not in Alaska. It's in Canada! Klondike gold may not have been found as beautifully crystallized specimens, but tons of it have been scooped up by argonauts. This led to plenty of successful prospecting elsewhere in the far north.

There's no way a brief review like this can encompass all of what Canada has to offer. But there are some species that are so common, so important, or so popular that we should address them.

Canadian jade comes almost exclusively from British Columbia, where it formed in metamorphic rocks, which also produce asbestos, tremolite, serpen-

The Jeffrey Quarry has produced some gorgeous vesuvianite crystals.

DA

One of the better sources for fine crystals of uraninite is the Faraday Mine near Bancroft, Ontario.

Amolyte is a fairly recent fossil gem discovery from Western Canada.

tine and the like. Keep in mind that "jade" is a general name applied to jadeite, which is rare in Canada, and nephrite, an abundant and lovely grass-green gem containing some black magnetite, chlorite and sometimes talc. Nephrite gets its tough properties from its composition, a fibrous mix of tremolite and actinolite. These fibrous minerals interlock to form a tight, tough rock that takes a wonderful polish and varies from a creamy "mutton fat" color to a deep, rich green. Remarkably, the chemical structures of these two minerals have identical ratios of calcium, magnesium, iron, silica, oxygen and hydroxyl radicals. The differences observed are due to actual variations in the amount of magnesium versus iron in the structure. The magnesium-rich type is lighter in color. Iron enriches the color to a superb green.

The main source of jade in Canada is north-central British Columbia. Two mountain ranges, the Ominecas and Cassiers, produce nephrite. Farther south is the Frazier River, a sometimes abundant source of jade. It produces stream-rounded alluvial masses, some of which weigh in at multiple tons. Jade is also extracted during hard-rock mining, the leading source of the gem. The Cassier Mine and mines at Dease and Cry lakes, south of Cassier, are the important operations.

continued on next page

Canada/ *from page 13*

Far to the east, the mainland portion of Newfoundland known as Labrador yields a gemmy variety of feldspar named labradorite, prized for its blue, bronze and multicolored flashes. It was originally known to local natives who, according to John Sinkankas, called it "fire rock." It was highly prized even then. About the time America was moving toward independence, Europeans obtained specimens of this lovely massive gem. Today, labradorite is found in quantity in the Urals, Greenland, Utah, California, Texas and New York, among other places. I can recall taking a spelunking trip near Gore Mountain, New York, when a new highway to Canada was being built. Hundreds of large boulders of labradorite were unearthed during the excavations. These were not quite as vibrant as the original Labrador material, but beautiful nonetheless.

lar with local collectors, who are allowed in only on scheduled club field trips. Superb salmon-pink serandite, which was rare until this source opened up, is perhaps the most attractive of the species from this quarry. Blocky prisms up to several inches long have commonly been found here. Coupled with the serandite, snow-white analcime crystals of enormous size may often be found, some approaching 6 to 8 inches across. The common mineral siderite forms in sharp rhombs of exceptional size, the larger ones approaching 10 inches on an edge. Some are penetration twins, and many have microcrystals of rarer minerals attached.

Among the rare minerals are catapleiite, a hydrous calcium zirconium silicate, and epididymite, a sodium beryllium silicate. Acmite is a more common species. Such minerals reflect the complexity of the original magmatic nepheline syenite

In its early days, Mount St. Hilaire produced wonderful rhombs of siderite.

For the serious crystal collector, I doubt any Canadian deposit is as important or as well known as the complex deposit at Mount St. Hilaire. Mount St. Hilaire is just one of 10 low hills that stretch from southeast of Montreal to within the city limits. The most noted sources in these hills are three quarries: the Francon Quarry, famous for its superb weloganite crystals; the Poudrette Quarry; and the more noteworthy Demix Quarry, from which nearly 200 different mineral species—many of them uncommon to very rare—have been collected.

The Demix Quarry is extremely popu-

rocks. These rocks were formed and solidified nearly two miles below the surface. Like so many rocks, they were later exposed, first by erosion, then by glacial action. More resistant than the surrounding rock, these magmatic deposits formed rounded hills called "manodnocks" as glaciers scoured the landscape.

Other minerals from the Demix Quarry include acmite and rhodochrosite. Acmite is another name for the species aegirine, a sodium iron silicate. These crystals are seen as long, black, needlelike blades, often penetrating other minerals. Rhodochrosite, best known in simple

bright-red crystals elsewhere, is so different here that a casual glance is not enough to identify it. With a flat, platy habit and unusual mahogany color, St. Hilaire's rhodochrosites are decidedly different.

Certainly, the mineral deposit that created the most excitement, and one that has left us with a legacy of mining lore and legend, is the 1896 discovery of gold on Bonanza Creek, a nondescript branch of the Klondike River in the Yukon. The rush to the Klondike came at a time when the economy needed a lift. There was considerable unemployment in the United States, and upwards of 100,000 people dashed north to strike it rich. Less than half actually achieved their goal. In three years, the gold was gathered and the rush ended. Because the bulk of the gold that was mined was alluvial, few noteworthy specimens have survived for collectors to prize. Yet, the rush triggered other rushes in the cold north, which brought to light other deposits of gold and other valuable minerals. From some of these deposits, we have fine examples of crystallized gold, stibnite, chalcocite, cinnabar and much more.

The search for gold in Canada goes on, of course. Alluvial deposits still yield a substantial trickle that is hardly a factor in the overall picture of world gold mining. Hard-rock mining for gold in Canada keeps it among the world's major gold-producing countries.

Gold is not the only precious metal Canada has produced. One of the great silver finds of all time took place in Ontario, hard by Lake Timiskaming on the Quebec border. During the building of the Timiskaming and Northern Railroad, intended as a means of getting produce to market faster, two timber cruisers found some odd-looking rocks. The rocks had a metallike content that would bend easily and, when bitten, showed tooth marks.

This bright, metallic material proved to be silver, and the ore contained upwards of 4,000 ounces of silver to the ton! A rush developed slowly. It took a couple more years for things to really boom, and when they did, huge masses of silver were brought out of the ground. It was not unusual for miners to encounter masses of nearly pure silver weighing over a ton! Veins of the metal a yard wide were common. In fact, during surface excavations, a vein of silver was exposed that was 3 feet wide; it became known as the "silver sidewalk!" Some of this particular material survived. A nice specimen resides in the Smithsonian Institution.

The Ontario mines were so rich that the apparently low-grade material was carelessly tossed out as dump rock. Since the silver occurred in calcite veins, later collectors searching nearly abandoned Cobalt mine dumps in the 1960s and '70s were able to collect masses of calcite which, when dissolved in acid, yielded wonderful arborescent silver specimens.

Most of the silver occurred as sheets of metal in veins and seams. Occasionally, wires were found, and some have survived. Masses of the host rock, a basaltic material, had sheets and masses of silver protruding from it. Such specimens are nice to have, but can hardly rival those from the great deposit at Kongsberg, Norway. Even the choice silver specimens that have survived from Silver Islet, on the Canadian shore of Lake Superior, near Thunder Bay, easily best Cobalt silver specimens for aesthetics. But Cobalt gains its reputation for sheer quantity of the precious metal, not for pretty specimens.

Thunder Bay is well known to collectors, as they can pay a small fee to collect fine amethyst plates. This deposit is important enough for amethyst to have been made Ontario's official mineral species. It is found as crystal points, just terminations with the side prism faces seldom visible. These points occur in narrow seams in granitic rocks that are heavily faulted. The color varies, ranging from none to a rich violet. Very little of the material is facet grade. One notable feature of the Thunder Bay amethyst is bright-red flecks of iron oxide included in the crystals. This does occur in amethyst in other deposits, but the Thunder Bay material is best known for this inclusion.

Canada is very well known for its huge asbestos deposits. "Asbestos" is a general name applied to long-fibered chrysotile. The nomenclature here is very confusing. Chrysotile is a form of serpentine, and that's not a recognized mineral. Serpentine is really a group of minerals, including antigorite, chrysotile, clinochrysotile and others. What's important here is that asbestos quarries—particularly the one in southern Quebec known as the Jeffrey Quarry—reproduce wonderful metamorphic mineral species. Marvelous specimens of rich cinnamon to orange grossular garnet, along with choice green to violet vesuvianite, occasionally come to light. A third mineral, diopside, is found less often, but in sharp tan to greenish crystals that are long and slender. The amount of rock removed here is massive, so good crystals of these minerals have been frequently found in the past. The garnets sometimes occur on white calcite. Others form as incompletely developed dodecahedrons, often gemmy, tightly intergrown in plates up to several inches in size.

Several zeolite and zeolite-associated minerals, apophyllite and pectolite are found in the Quebec quarries, often eclipsed by the more notable species mentioned above.

continued on next page

Canada! *from page 15*

When we journey to the far, far north of Canada, to a place in the Yukon Territory called Rapid Creek, we find several very fine phosphate species. The government put a stop to collecting these minerals to prevent environmental damage. Best known are wardite and lazulite, two rare species. Lazulite was very rare until the Rapid Creek find yielded superb crystals of this rich blue mineral in small plates, eminently suited to collecting. This mineral is now the official gemstone of the Yukon Territory.

Wardite is somewhat more drab, being an off-white to cream color. Sharp crystals to a half-inch, again in platy groups, have been collected here. But chances are that what has come out will be the only specimens collected, at least legally, as collecting is now forbidden.

For fluorescent collectors, there are plenty of brightly responsive minerals to be found in Canada. One unusual material is hackmanite, found along the York River near Bancroft, Ontario, in years past. When freshly broken, it has a violet-pink color, which fades rapidly. Put the piece under ultraviolet lamp, and it glows a rich peach color. Turn off the lamp, and you'll see the original violet-pink color has returned, only to fade again. This property, called tenebrescence, is very unusual and always interesting to observe.

Another brightly fluorescent mineral from Canada is meionite, a variety of scapolite. Meionite ranks among those minerals that give the brightest response under long-wave ultraviolet light. It glows a brilliant yellow. Years ago, I went searching for this mineral north of Montreal. I was successful, finding outcrops along a dirt road perhaps 100 miles from Montreal. It was early in the summer and the black flies were brutal, but I persevered, collecting a car trunk full of the material at night. I did not leave the collecting site until perhaps 2 a.m. as I was doing so well. When I finally got back to the paved Queen's Highway between Ottawa and Montreal, I was pulled over by provincial police. They asked what we had in the trunk, so I showed them, hauling out a portable UV lamp. They were quite impressed. When I asked why they had stopped me, they said they thought I was a burglar with a safe stashed in the trunk!

Perhaps I saved the best for last: the Bancroft District. The city of Bancroft, Ontario, is the hub of a variety of mines, which have yielded wonderful minerals that have gained world-wide notice. Joel Grice, in his very useful and superb book *Famous Mineral Localities of Canada*, which I strongly recommend, calls Bancroft the "Mineral Capital of Canada." So there must be some pretty nice stuff found there.

Fine Mount St. Hilaire serandite in a matrix of black acmite from the Zinn Collection.

My favorite mineral from the Bancroft area is calcite from the Faraday Mine. These calcites were large scalenohedrons, some so large they had to be broken up to haul them to grass. They all had a rich brown goethite coating. When broken into cleavage fragments, the water-clear calcite was seen to have wavering crystal growths of marcasite starting from a crystal face and extending inward like so much seaweed. You still see an occasional cleavage of this material, but the Faraday uranium mine has long since been closed.

Another choice gem from the Bancroft area is bright-blue sodalite, originally mined at the Princess Quarry. Now closed, this quarry once produced huge masses of superb cutting and carving material.

The people of Bancroft have, for decades, held an annual Rockhound Gemboree. Attending the show is a wonderful opportunity to visit the many mineral sources in the area where you could collect sodalite, hackmanite, fluor-richterite, calcite, apatite, and even radioactive minerals, if you so desire. The Matawaska Mine, for example, was one of the great sources of bright-yellow uranophane needles, and some of the sharpest cubes of uraninite I've ever seen came from this region.

There is no doubt Canada has produced great mineral specimens for collectors and is a worthwhile place to go collect, as it is still producing specimens. The attitude in Canada still favors mining, unlike the general attitude here in the States that mining is at best a necessary evil—an unfortunate attitude to say the least. The only caution I offer is to wait until the spring black fly season is over—the bites you collect seem to persist all summer!

Shop Talk

by William A. Kappele

GRINDING MACHINES

While it is surely fun to go looking for a nice rock to haul home, and even more fun to cut some slabs from the rock and see a little of the beauty hidden inside, the real fun begins with the initial grinding. It's at this stage that your rock begins to look like the shining cabochon it will become. If you already have a grinding machine, you're ready to start, but if you still have to make that purchase, it's a good idea to look at the various machines on the market. You may even decide to make your own. There was a time not too long ago when virtually all lapidaries made their own equipment.

Grinding machines come in two basic configurations: those with vertical wheels or discs, and those with horizontal discs. The method of holding the stone while grinding is very different from one machine to another. If you have a chance, by all means go to a shop or a club where you can try out the different types. Nothing is less enjoyable than spending the milk money for something you don't like.

Probably the most common machine is one with a vertical wheel on an arbor with a detached motor. These machines usually have a long arbor with grinding, sanding and polishing wheels, all of which are run by the same motor. This eliminates the hassle of changing wheels for the various operations. The biggest disadvantage of wheels is that it is very difficult to grind a flat surface on them.

Horizontal discs were once popular for hobbyists who didn't have a lot of room to operate, but it is hard to find one today. Their bigger cousin, the flat lap, is used to grind, sand and polish slabs. Vertical discs are popular for space-saving applications. Their main disadvantage is that discs and pads must be replaced for each operation.

Regardless of which type of machine you choose, you will have to have either grinding wheels or discs. Discs are available only in diamond, while wheels come in both diamond and silicon carbide. Silicon carbide, a man-made abrasive, was discovered in 1891 by scientists looking for a way to make artificial diamonds. Actually, they came pretty close, since it is almost as hard as diamond.

Like its close relative aluminum oxide, silicon carbide fractures in use and exposes new points as the old ones break off. This is good, because it keeps the cutting action going, but bad because the wheel wears down and becomes bumpy and grooved. Lots of early lapidaries kept their carbide wheels true by varying the pressure on the stone and the position of the stone on the wheel, but I like to spend my time concentrating on the stone I'm cutting and not on keeping the wheel true. There are many good diamond truing devices on the market, though, and if you decide on silicon carbide, you will not have a lot of trouble keeping your wheel in good shape.

Keeping your fingers and thumbs in good shape might be more of a challenge. Silicon carbide is an excellent cutting materials for all kinds of things—including flesh and bone. Diamond, on the other hand, is more forgiving of little slips. When I finish roughing out a cab on my diamond disk, I have a few facets on my thumbnails. With silicon carbide, I wouldn't be able to hitch a ride.

Diamond is more expensive, but the wheels don't wear down or need truing. Way back when I first decided to get into lapidary, an old-timer told me to buy diamond if I didn't have any equipment yet. I think he was right, but a lot of people will not agree. If you can, try both before you decide.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle3@home.com, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

Prospect Park Kyanite

An Urban Philadelphia Collecting Site Produces Fine Blue Crystals

by Robert Beard

The lowlands near Philadelphia International Airport should be the least likely place for a mineral collecting trip. The area has everything against it. The place is covered by commercial development, plus several major industrial plants, a huge airport, and even a gigantic refinery complex. Most people who come here are in transit, as evident by the sheer number of hotels and the constant departure of planes from the airport. Those who have to stay hide in the developments around south Philadelphia and do their best to deal with the traffic, the noise, the crime, and the pollution.

"Flat" best describes the topography. To the untrained eye, and to many uninformed geological eyes, the area looks like it only consists of fill and floodplain sediments from the Delaware River. However, like Manhattan Island and many other great urban areas, it is underlain by crystalline rock. Crystalline rocks can provide an incredibly stable platform for houses, buildings, factories and skyscrapers.

Areas of older crystalline rocks often contain significant amounts of unusual minerals. Since they have been around a long time, they have often been folded, sheared, melted and intruded by other rocks. The rocks in southeastern Pennsylvania are no exception. The crystalline bedrock complex includes schists, quartzites and gneisses, and the metallic and nonmetallic mineralization has been extensive. Many of the copper, lead and iron deposits in these rocks played a crucial role in early industrial America. Corundum, garnet and graphite were also mined, and deposits of serpentine and pegmatites were also found. These days, industry exploits the hard and consistent nature of the rock itself, as several quarries in the Philadelphia area mine the crystalline bedrock for crushed stone.

Much of the crystalline bedrock in the Philadelphia area is part of the Wissahickon Formation, which is a Cambrian-age metamorphic sequence of schists and quartzites. The Wissahickon schists are well known for their excellent garnets. There are also sections of the formation where the rock composition and metamorphism have been ideal for forming kyanite.

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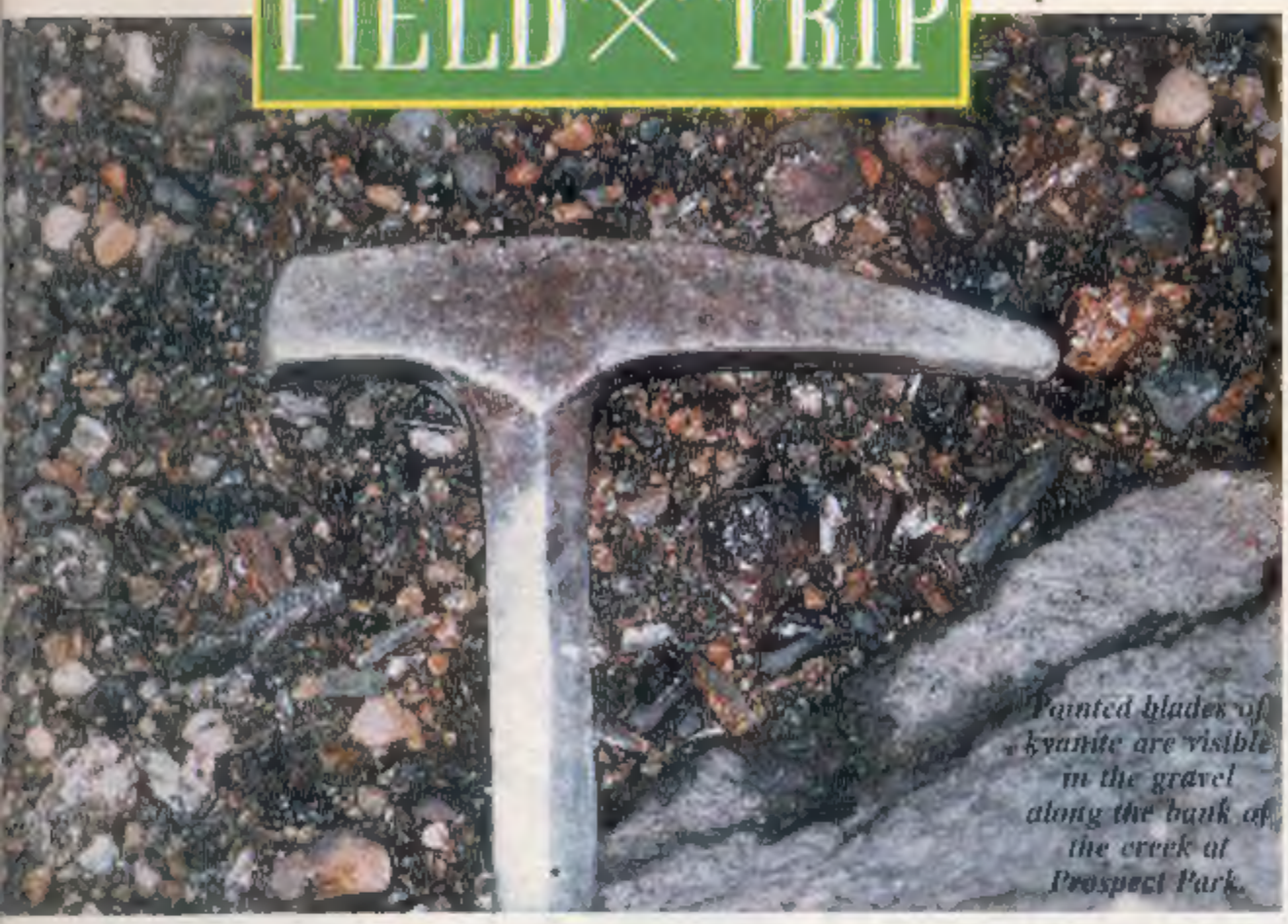
Breaking off the biotite and quartzite host rock reveals blue blades of kyanite. (Photos by the author)

FIELD TRIP



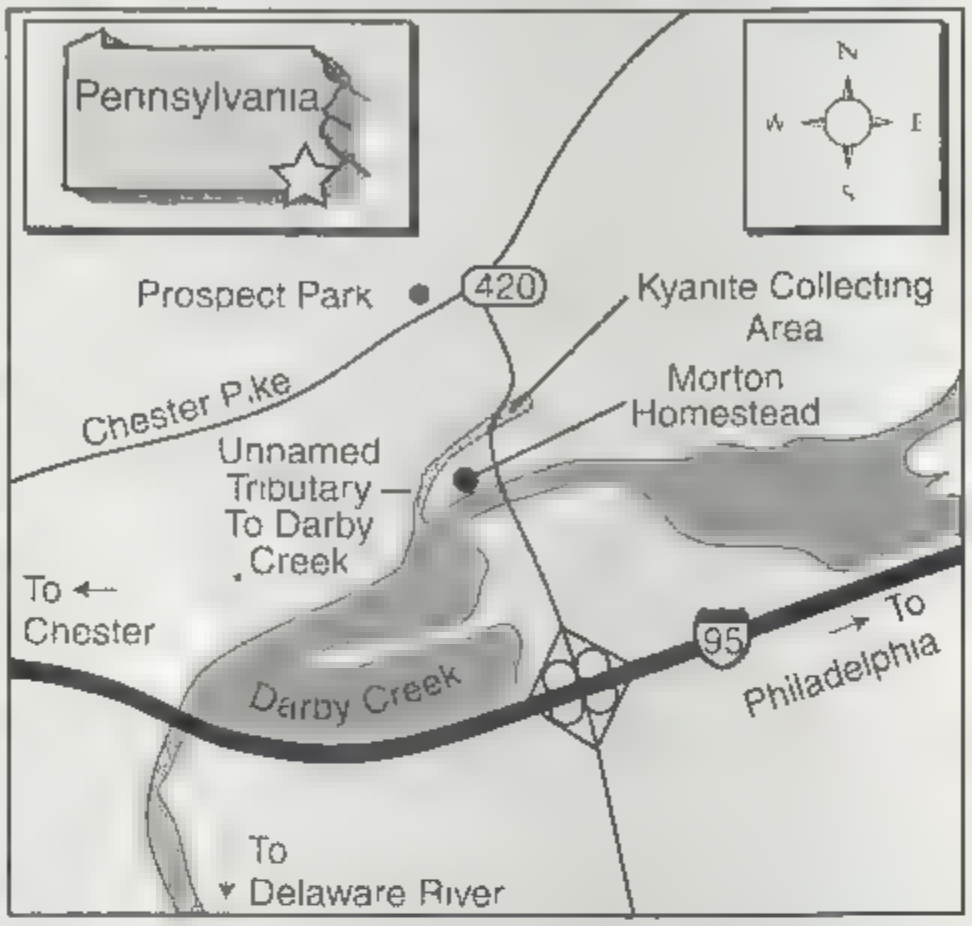
Painted blades of kyanite are visible in the gravel along the bank of the creek at Prospect Park.

Typical kyanite blades found in and alongside the stream.

This unnamed tributary of Darby Creek is an abundant source of kyanite blades. Hunting can only be done when the water level is low.

Prospect Park/ *from page 28*

Kyanite is a mineral that typically occurs as long, thin bladed, blue crystals in high-pressure metamorphic rocks that are rich in alumina and silica. The name comes from the Greek word "kyanos," meaning "blue." While the mineral is often blue, it sometimes ranges in color from dark gray to light green. The blue of metamorphic kyanite is due to trace amounts of Fe^{+2} and Ti^{+4} impurities substituting for aluminum. Kyanite is occasionally found in kimberlites, as well, and the light-blue color of these kyanites is due to trace amounts of chromium.



Its chemical formula is Al_2SiO_5, and it is a polymorph with andalusite and sillimanite. A polymorph is a mineral that shares the same chemistry with one or more minerals, but crystallizes in a different structure. Kyanite, andalusite and sillimanite form at different temperatures and pressures, and metamorphic petrologists recognized that the formation temperature and pressure of metamorphosed aluminous rocks could often be determined by determining the Al_2SiO_5 polymorph present. The presence of kyanite typically indicates that the rock formed at higher pressures and lower temperatures relative to the formation of the other polymorphs.

A unique characteristic of kyanite is a wide variation in hardness in the same crystal. The Mohs hardness is approximately 4.5 when scratched parallel to the long axis of the crystal, and approximately 6.5 when scratched perpendicular to the long axis. This difference in hardness is due to variations in the mineral composition and crystal structure. Diamond is another mineral that exhibits variations in hardness within the same crystal, and diamond cutters take advantage of this. Kyanite gems of fine color and transparency are rare, and since the relatively low hardness and well developed cleavage make it comparatively easy to damage, its use as a gemstone is generally limited to earrings, brooches and pendants.

Although kyanite is not a household name, most of the products that are made of or made possible by kyanite are important in everyday life. Kyanite goes into ceramic kitchen tiles and electrical insulating porcelain, and makes up the abrasive element in railroad brake shoe pads and the heat-retaining material in ceramic pizza stones. The refractory industry consumes the vast majority of kyanite, using it in the manufacture of heat-resistant bricks, mortars and sprays. Kyanite undergoes a large and irreversible expansion when heated to a relatively low temperature (1,325 degrees Centigrade), and this expansion is used by many refractory and ceramic manufacturers to reduce shrinkage during initial firing and produce a stable material.

The world's largest producer of kyanite is the Kyanite Mining Co. (KMC) of Virginia. Kyanite is also produced in Australia, Brazil, India, Kenya, Sweden, Zimbabwe and parts of the former USSR. The kyanite produced by KMC is exported, as well as used domestically, one of the few instances in which an American producer of industrial minerals exports its product. Undoubtedly, many of the foreign-made products that use American kyanite are shipped right back to consumers in the United States.

Although kyanite is present in the Wissahickon Formation, it was never present in quantities that could justify mining in the Philadelphia area. However, its unique bladed habit and blue color have made it a very collectible mineral. Development of the area has undoubtedly destroyed and covered some of the best kyanite bearing areas, but like many urban areas, parks and woodlands with streams and outcrops can still be found.

An outstanding area for collecting kyanite from the Wissahickon Formation is located at Prospect Park near the Morton Homestead, which is just west of Philadelphia International Airport. The area is described as a collecting locality in *Gem Trails of Pennsylvania and New Jersey* by Scott Stepananski and Karenne Snow (Gem Guides Book Co., Baldwin Park, CA). The kyanite is found in loose blades and in rocks along the banks and bottom of an unnamed tributary to Darby Creek on the north side of the Morton Homestead.

My first trip to the area was in the summer of 2000. I was with my wife and our two children, hoping to find a place where they could pick up kyanite blades. We found that parking at the Morton Homestead, which is a historical site administered by the Pennsylvania Historical and Museum Commission, was good, and it seemed reasonably secure. The Morton Homestead site is set up as a small park, and it is a welcome respite from the traffic around Philadelphia.

Unfortunately, during our visit the unnamed tributary was extremely high and muddy, and we could not even see any small pieces near the side of the creek. During the summertime, the brush along the creek becomes extremely thick, and the thought of ticks and poison ivy kept us from doing any bushwhacking. We had to write this visit off as one of our unsuccessful trips. Any return trips to the area had to be timed for when the water was low.

I finally had the chance to return to the area in June 2001, when the jungle along the banks was already pretty thick. However, the small trails that led to the unnamed tributary to Darby Creek were still visible. This time the creek was much lower. I was able to walk along the banks for a short way, but the kyanite was certainly not jumping out at me. Finally, I was able to see a couple of small blades in the gravel along the banks. Glad that I had my old shoes on, I entered the creek and began to work my way upstream.

Mineral collecting in places within or adjacent to urban areas, especially along streams, has another drawback. Streams that drain areas that are heavily developed are often heavily polluted, and this creek was no exception. Collecting here is not for the squeamish. The creek bottom is littered with bottles, cans, broken glass, tires and other discarded items. From my work as an environmental geologist, I also know that the water quality of such creeks can also be pretty nasty. Levels of coliform and other bacteria are generally high, and you should not get into the creek if you have any open cuts on your legs or hands. Because of the trash and water quality, I also would discourage collecting in the creek with children under 8 years old, since it is too easy for them to get cut on a piece of glass or metal or fall into the water.

I had a rock hammer with which to dig along the sides of the bank and within the stream. To protect myself, I put on a pair of rubber gloves, the type hardware stores sell to painters. Normal work gloves would get wet in the creek and

continued on next page

Prospect Park/ *from page 31*

would not protect my hands from the water. Of course, rubber gloves are no defense against broken glass, so I had to be careful when digging in the creek.

Some of the most striking rocks in the creek are the large boulders with fist-size potassium feldspars. These rocks were most abundant in the area where the trails from the parking area enter the creek. The feldspars have weathered less than the host rock, and they protrude from the sides of the boulders. I checked to see if these rocks also had some good kyanites, but I did not see any. I only had a hammer, but I thought that a combination of a hammer and chisel would allow the removal of some big feldspars. The feldspars are cream to light orange, and generally form an irregular contact with the enclosing rock. Muscovite and biotite are also abundant in the rocks with the feldspars.

As I went farther upstream, I saw more and more kyanite blades in the gravel. The kyanite is very distinct, and the loose blades are generally an inch long and ¼ to ½ inch wide. I collected them in a film canister, since they were too wet to place in a pocket. Conversations that I had with *Gem Trails of Pennsylvania and New Jersey* author Karenne Snow indicated that better kyanite was available on the north side of state Highway 420, and I continued upstream to check this area out.

To get to the other side of the highway, I continued along the creek until I reached the road. The creek goes beneath the road through a concrete tunnel. This tunnel is approximately as wide as the creek (20 feet), but it is only about 5 feet high and about 200 feet long. The water was shallow enough for me to easily walk through the tunnel, but it was obviously a place to stay away from if the water was high. I had to stoop over to get through, but at the time of my visit at least there were no spiders or other creepy arachnids. Spider season in southeastern Pennsylvania is around mid-August through September, and this looked like the type of place that might be full of them at that time.

As I emerged from the tunnel, I saw an apartment complex on the south side of the creek, and woods with some more commercial development to the north. Though I did not see any No Trespassing signs, I made certain that I stayed within the creek and away from the apartments. No one bothered me, and I made certain that I did not bother anyone else.

As I worked up the creek, I continued to see more kyanite blades on the banks and in the water. What I really wanted to find, though, was a large piece of blue kyanite that was still within its enclosing rock. In addition to being a prize specimen, such a rock could also lead to clues as to where to find the best kyanite.

I found several large pieces of kyanite schist, and when I broke them open I saw several blades of kyanite 1 to 2 inches long and about ½ inch wide. The kyanite was dark blue gray, almost black. It was not the bright blue kyanite that I had been led to believe was present in the area.

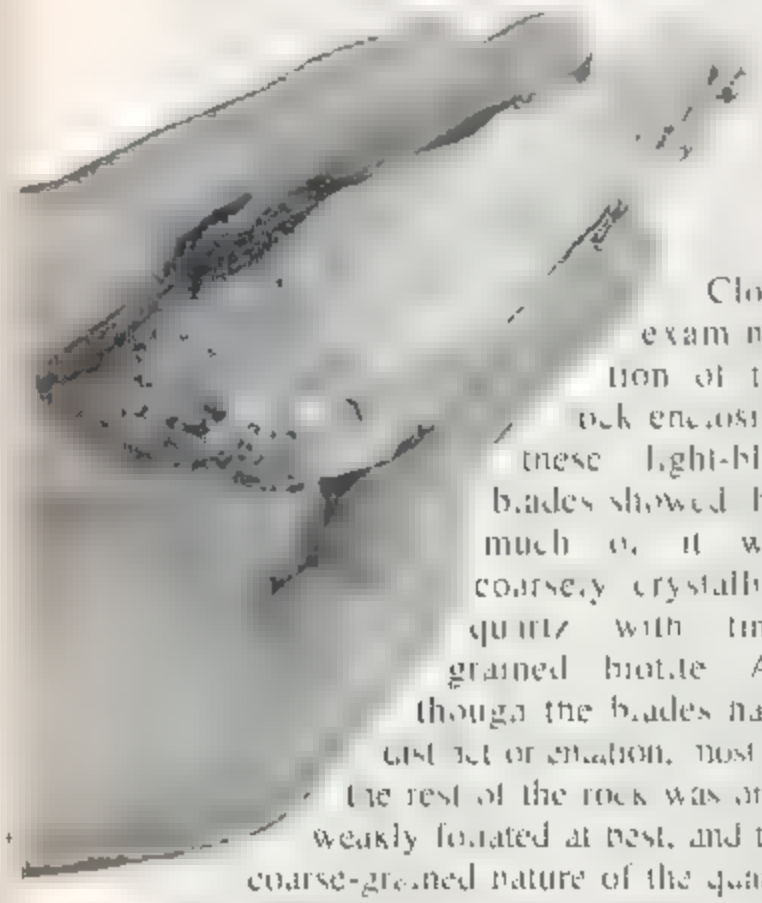
Suddenly, on the south side of the bank, I found a rock with an unusual pointed end. At first it looked like a piece of wood. A bundle of elongated crystal blades formed the point, and I could feel that it was extremely dense when I picked it up. I had found my specimen of intact kyanite. Rather than hammer and chop up the bladed end immediately, I whacked the bottom section of the rock off to get rid of the waste section. I then carried the manageable section.

I continued up the creek for several hundred more feet, but did not see any similar rocks. I found that the schist was abundant, and in some places the stream bottom bedrock was kyanite schist. The kyanite blades formed a striking pattern, and while they were not oriented perfectly, they generally trended in one direction. Since I only had a hammer and not a chisel, it was not easy to remove any of the in place schist. A flat bladed chisel and good hammer would have enabled me to take out some good, intact pieces of schist, and the intact pieces have the biggest kyanite blades. Since the kyanite is slightly less prone to erosion than some of the surrounding minerals in the schist, the faces of the schist that are eroded often show the kyanite blades the best. This is true of similar metamorphic rocks that contain garnet or other hard metamorphic minerals. And although the kyanite is hard, the surrounding micas are soft and easily scratched, so one should keep any collected rocks from scratching each other.

After I returned home, I carefully evaluated the blades and rocks I had collected. The kyanite blades were all dark-gray to black with just a hint of blue. I used a combination of CLR and Super Iron Out (obtained at the local hardware store) to remove the minor iron staining, but it did not have a significant effect on changing the color of the blades. I broke up some more of the schist pieces, and found that while blades were abundant, they were still all dark gray to black.

Finally, I had the chance to carefully evaluate the unusual pointed piece that I had found. Like a diamond cutter, I evaluated the best place to make the initial tap with my hammer. Not having a saw, I would have to use my flat bladed chisel to slice off a piece. I positioned the chisel and broke off a section of the blades near their base.

I was shocked when I saw the inside of the blades. The interior was a bright light blue, far brighter and more colorful than the dark blades I had collected in the creek and pried out of the schist. The crystals were a mass of fiberlike aggregates that were nearly 6 inches long in parts of the rock, but most of them were 3 to 4 inches long. They were a translucent blue, and oriented so that different faces reflected the sunlight like glass. The blades looked similar to fibrous specimens from an asbestos mine, but they were a bright light blue instead of the white to green of asbestos. I had never seen anything like them.



Close examination of the rock enclosing these light-blue blades showed that much of it was coarsely crystalline quartz with fine-grained biotite. Although the blades have distinct orientation, most of the rest of the rock was only weakly foliated at best, and the coarse-grained nature of the quartz suggested that the rock may have come from a pegmatitic section of the schist.

Although this rock was found in the creek, it was apparent that the light blue blades would never have withstood the weathering in the stream bed if they had been broken off. This suggests that the best blue kyanite in the area may be found in outcrops or in large, loose rocks in the creek. Blades of kyanite that are found in the creek are likely to be the black blades that weather from the schist, and the delicate blue blades that I found attached to the rock may be very difficult to find loose in the stream bed. Any future trips I take to this locality will focus on finding large pointed rocks that indicate aggregates of intact kyanite.

To get to this locality, take the Interstate 95 exit for state Highway 420. Head north on state Highway 420 for approximately one-half mile. You will soon cross a bridge over Darby Creek. The Morton Homestead will be on your left, however, left turns into the Homestead are not allowed. You will have to go farther north, make a U-turn, and then turn into the parking area for the Homestead park from the southbound lane. Faint trails lead the parking area to the unnamed tributary. As long as the water is low, and you are persistent in your search, you should be able to come home with some excellent blue kyanite.

Upgrade Your

Save Money by Converting Old Equipment

by John Braden

If you are like me, a rockhound with limited funds, and you have some wonderful material that that just cries out for a saw of adequate size, what do you do? You find a wreck and you seize the opportunity.

The previous owner of this 18-inch beauty had only just started to clean it up. It was a monstrosity, with the motor mounted on a board at the rear of the tank, the lead screw-drive motor sticking out in front, preventing the operator from standing close, and some kind of an end-of travel controller also looming large out the front, but I refused to be discouraged. I decided to upgrade my "new" previously owned rock saw into something more useful.

First, I had to get down to the nitty-gritty: the cleanup. I wanted to refinish this rock saw inside and out, so the first thing I did was disassemble, and I mean right down to the bare tank: dispense with the motor mount and end-of-travel thing, hood off, window out, rails off.

Next, out came the putty knife, scraper, etc., and I chipped away at the settled and caked rock dust. I gave it a final wash with what has become my universal solvent, acetone. (Since this chemical is a major requirement for meth labs, I sneak in and out of the local hardware store when ever I buy another gallon of the stuff.)

A simple angle bracket screw mounted to the tank sides keeps the handle in the up position. (Photos by the author)

Next, I had to plug the extra holes for the previous motor mount at the rear, and for the carriage drive motor at the front. Here's my secret. On the inside of the tank, place either masking or scotch tape over the holes. Mix a little automotive Bondo™ and trowel it into the holes on the underside. When the epoxy has set, sand it flush, remove the tape, and voila: no holes when painted.

With the tank spotless and the holes plugged, it was time to coat the inside with epoxy appliance paint and hope it would withstand oil soaking; at least this will give it plenty of time to harden.

While the appliance paint is hardening, it is a good time for the welding operations. In order to be able to easily move the saw, even with 9 gallons of cutting oil in it, rear wheels in optional up or down position and a hold-down handle in front are needed. With the type of handle about to be described, even my underweight son is able to move the entire assembly easily.

To construct the handle, a length of black iron pipe is given a couple of miter cuts and welded together. A drilled tab is welded to either side, and the assembly is held in place by pivot screws driven into the front legs. Constraint in the up position is accomplished by a simple angle bracket screw mounted to the tank sides.

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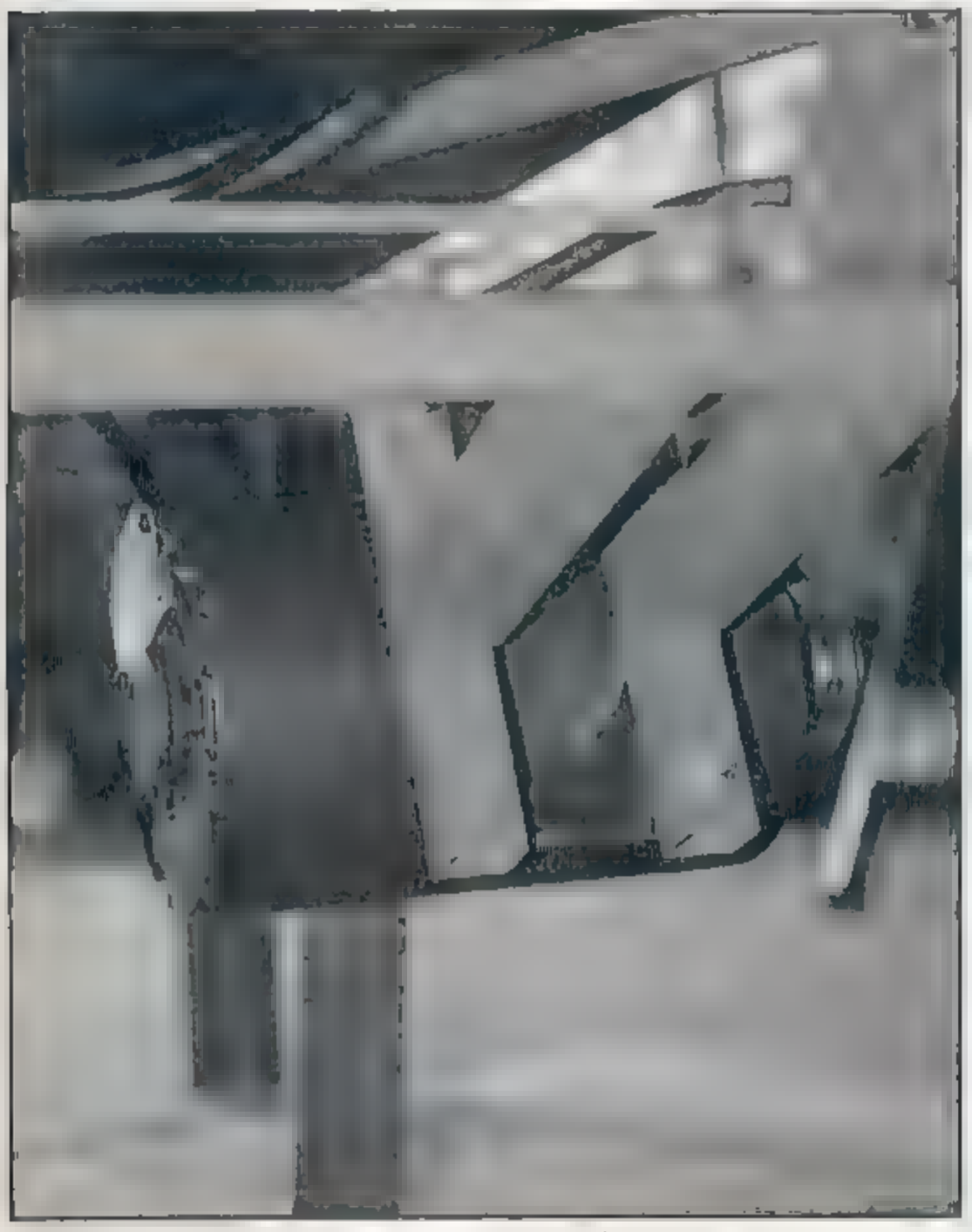
Rock Saw

To add wheels, drill short sections of square tubing for the assembly bolt and weld them to the rear legs.

MATERIALS:
Conduit or black iron pipe
Conduit boxes and fittings
Threaded rod (¼ inch)
Square tubing
Wheels and rod or axle
Toggle switch and spring
Beaded chain
Three pole electrical plug
Appliance paint
Silicone sealing
Bondo™
Solvent

TOOLS:
Hacksaw
Scraper
Assorted screwdrivers and wrenches
Threading taps and dies
Welding equipment or friendly welding shop (not a problem if you're also a silversmith)



A pair of square tubing T's welded to a length of conduit serves as a motor mount

Two different size short lengths of tubing provide a slider on the pivoting motor mount and a slider on a second rod at the top.

Upgrade! *from page 34*

For the up-down wheel assembly, short sections of square tubing are drilled for assembly bolts and welded to the rear legs. The toggle arms are made from either a section of channel or the next size of square tubing, and are trimmed to permit rotation. With the toggle arm rotated in the down position, the wheel axle rests under the fixed arm. Lifting the front handle permits the saw to be rolled. When the axle is rotated up and held in place by a length of screen door spring, the legs are on the floor.

Now, to the motor mount. I welded a pair of simple square tubing Ts to a length of conduit. The entire assembly rides on bolts threaded through the rear legs on either side. Riding on these pivots, the weight of the motor tensions the main drive belt.

The carriage drive is a bit trickier. When I removed the motor, the carriage lead screw needed to change ends, but the 7 rpm motor had to remain in the same relative orientation to preserve the direction of drive screw rotation. I welded two different size short lengths of tubing to the motor mounting plate, providing a slider on the pivoting motor mount and a slider on a second rod at the top. To tighten the belt, a threaded rod was also mounted between the rear legs. A wing nut rides on the threaded rod and pushes the mount to the proper position.

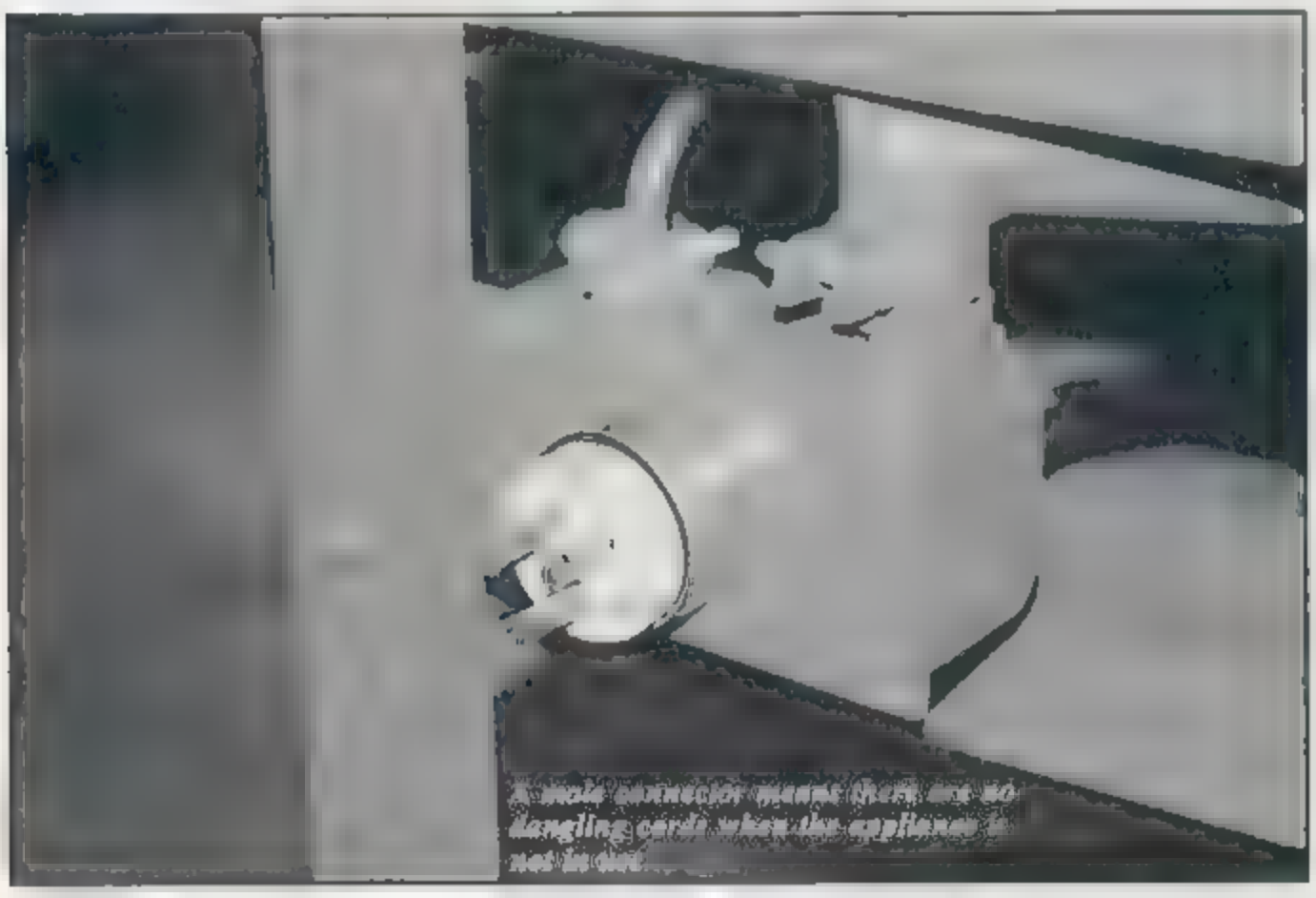
A couple additional touches were a control box switch with a power-on light and a box for the end-of-travel switch. The boxes are metal conduit boxes. The end-of-travel control is a heavy-duty toggle switch working against an axial spring mounted on the control rod, which runs between the toggle arm and the box bottom. The rod then passes through the tank wall and ends in a bead chain attached to the carriage. Also, I always like to have appliances with a male connector (no dangling power cords when not in use).

I'm too cheap to buy $3 or $4 conduit pull boxes for the conduit running beneath the tank. Right-angle welds on light-walled conduit suffice for my project.

If, as in this case, you would like a 20-inch saw instead of an 18-inch, a notch cut in a rear carriage bar mounting flange will give you that option, providing your tank is deep enough.

After painting and reassembly, don't neglect to reseal the viewing port with silicone rubber and *gently* bend the fingers back around the plate glass.

I have so far neglected to state the obvious, like inspecting the saw bearings for noticeable wear, replacing them if necessary, and polishing the carriage rods. Check the final alignment of these rods so that they are absolutely parallel to the plane of your saw blade by using a feeler gauge as you push the carriage past the blade diameter.



I made motor mount Ts so that they are to dangling cords when the appliance is not in use.

I'm too cheap to buy conduit pull boxes, so I constructed my own out of light-walled conduit.

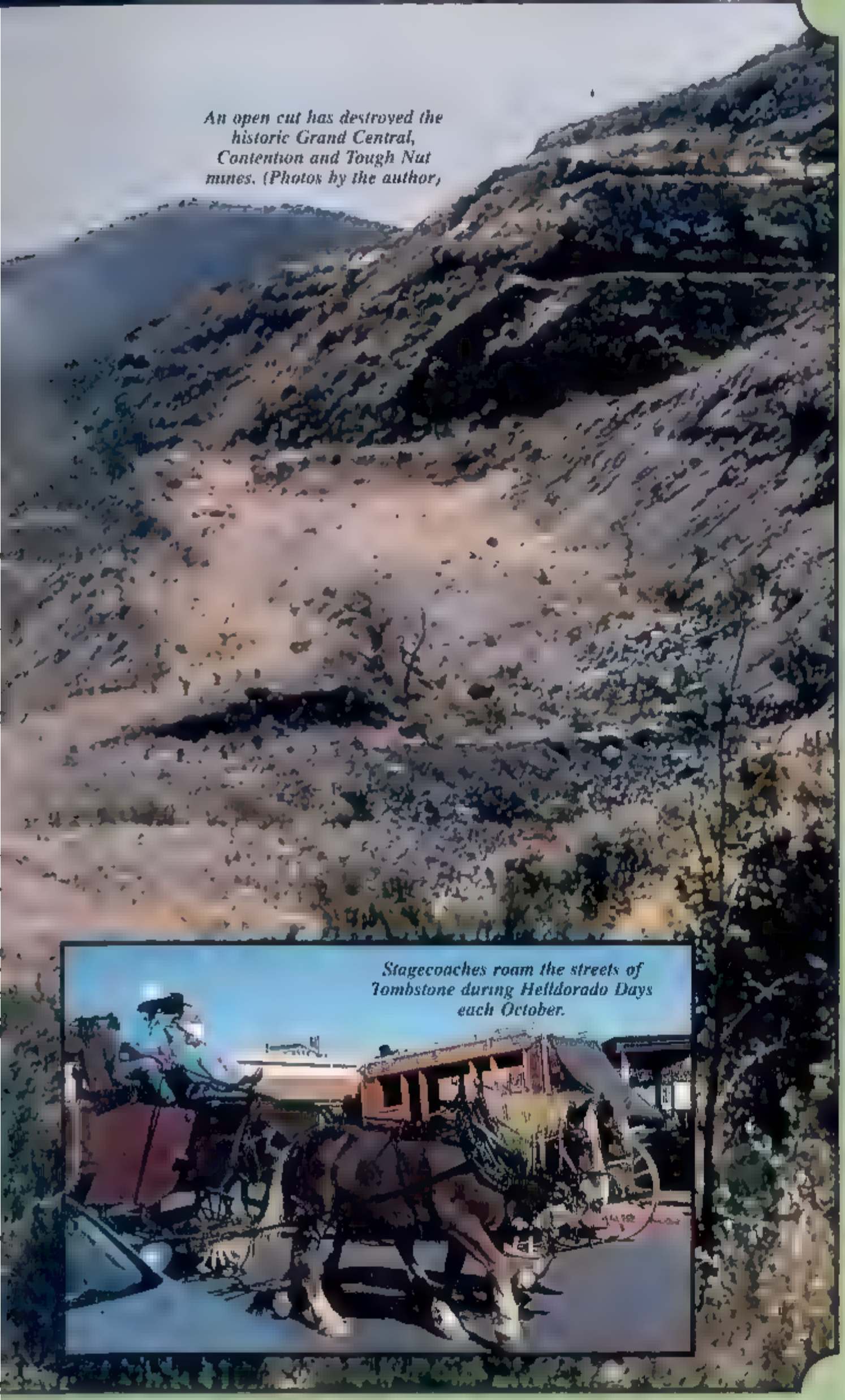
Cutting a notch in a rear carriage bar mounting flange may allow you to upgrade to a 20-inch saw.

Gallows from the historic Tombstone courthouse. (Photo courtesy the City of Tombstone)

Wooden headframes still stand in the Tombstone Hills.

Prospector Ed Schieffelin's tomb and monument, two miles outside of town.

THE TOWN TOO T



An open cut has destroyed the historic Grand Central, Contention and Tough Nut mines. (Photos by the author,

Stagecoaches roam the streets of Tombstone during Helldorado Days each October.

Tombstone's History Is Rich in Silver and Western Lore

TOUGH TO DIE

by Roger McPherson

A man wearing a red bandanna cruised by in a white Buick. "Hey, cowboys!" he yelled at two gunslingers on the boardwalk. He deftly maneuvered his car around the Tombstone stagecoach and disappeared. In the blazing sun on another street corner, a man in black frock coat and white shirt handed out fliers.

"Folks, we're goin' to have a gunfight at noon."

A passerby nodded. "Saw it yesterday. It's good, but dusty."

I sidled up to the man in black and timidly asked him who he was.

"I call myself Parson Brown," he answered, giving me a penetrating look. Seeing me eye his holstered gun, he continued. "I wear a gun because I do most of my preachin' in saloons."

"Seems like a lot of men wear guns around this town,' I ventured.

"There's five different gunfighter groups in Tombstone," the parson explained. "The Tombstone Vigilantes, Ambassadors of Tombstone, Boot Hill Gunslingers - they do the O.K. Corral every day at two o'clock - and the Cowboy Mounted Shooters. I belong to the Tombstone Cowboys. We're the national and state champions," he proudly claimed.

"Every day we do a skit at the Helldorado Lions Club set. We charge admission and give a percentage to the Lions for charities. It's family oriented. We don't come out and shoot everyone. We have a story line. A gunfighter finds a mule in the desert and brings it into town. The prospector comes looking for his mule. There's complications, but it's not just bang, bang, bang."

He pulled out his gun, and I wondered if I'd been too nosy.

"This here's a reproduction of the 1861 Samuel Colt .45. It was the start of Colt making cartridge revolvers." He spun the barrel before replacing the weapon. "It's expensive to dress in period clothing," he confided. "Add in gun leather and a good gun, and you're talkin' $1,000."

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Too Tough/ *from page 45*

Tombstone is steeped in the fun of the western frontier. You can get your youngster deputized, arrest and lock up your friends or spouse, and arrange for a hanging. There are daily gunfights, and the action packed Helldorado Days are held in late October every year. For an exact date and more information, call the Chamber of Commerce at (888) 457-3929 or the Office of Tourism at (800) 457-3423.

Tombstone traces its beginnings to the persistence and ability of one remarkable prospector. Two miles west of Tombstone, under an imposing tower of cemented granite boulders, Edward Schieffelin is buried in his favorite, worn clothing, along with his pick and canteen. He requested the tomb be built to resemble the corner monument of a mining claim. Located at last the outcropping granite that treated the rich silver deposits, it's a fitting resting place for a prospector. Schieffelin wished to be buried in the granite dells where he had first camped before making his discovery. For a few moments I sat beside the grave, paying my respects to this legend who searched these hills in 1877 with two mules, a rifle, and a meager supply of food. In a recollection of this period of his life, he declared: "I had a good outfit and made up my mind, no matter what occurred, I would live off my rifle until I found a prospect."

In the historic Courthouse Museum in Tombstone, Schieffelin's old .44 caliber Henry is on display. Its heavy octagonal barrel, brass breech, and copper plates holding the wooden stock together attest to a life of hardship. An old photograph shows the prospector about to drink from his canteen. His black, curly hair reaches to his shoulders, and his unkempt beard is thickly matted. People remembered his worn-out and patched clothing, and his slouch hat pieced together with rabbit skin.

Using Fort Huachuca as a supply base, he worked his way into the Tombstone Hills always in danger of marauding Apaches. Geronimo and a band of 40 warriors and 150 old men, women and children often raided across the Mexican border and hid out in the Dragoon Mountains east of Tombstone. Ranchers and prospectors left the area, but Schieffelin stayed, living on deer.

Soldiers at the fort said he would only find his tombstone out in the rabbit brush and mesquite, so the first claims he staked were named the Tombstone and the Graveyard. From the rich float and granite outcrops, he knew there had to be other lodes in the area, but only the Tombstone had silver. He went to Tucson to get supplies and showed the samples around to businessmen who had some knowledge of mining and ores, but none of them were geologists and they didn't recognize the silver sulfides.

Destitute and sick of his plain diet, he got a job at Globe, Arizona, and then he went to find his brother at a mine 300 miles away. The mine had just hired Richard Gird, a trained mining engineer and geologist. He assayed Schieffelin's samples and was convinced that this was a rich find. With a handshake, the three men agreed to share equally the results of their venture.

The three partners drove a wagon back to the Tombstone Hills, and the brothers methodically searched for outcrops while the assayer tested each day's samples. Their first strike was the Lucky Cuss, a 7-inch-wide vein of silver and gold extending for 50 feet. When Gird discovered it ran $15,000 to the ton, he called Schieffelin a "lucky cuss" and the name was adopted.

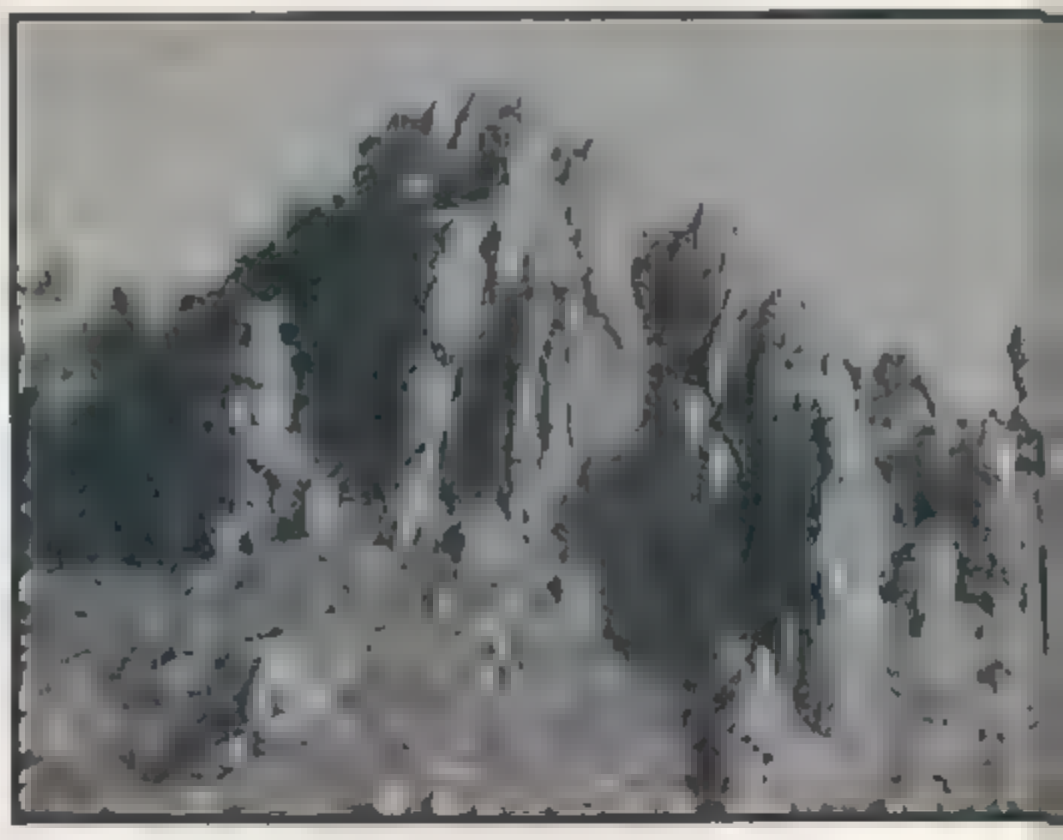
Schieffelin then estimated the trend of the buried structure, and a mile from the first vein he found surface float, which he traced to its origin. He said it was a "tough nut to crack," giving the Tough Nut Mine its name. While his brother and the assayer went to Tucson for supplies, Schieffelin built an adobe structure on the claim.

Two discouraged prospectors, Hank Williams and John Oliver, were about to give up their search in the same area, but Gird convinced Williams of its potential. Samples Williams had brought to Gird only had low-grade silver. An agreement was made that Williams would continue prospecting and file joint claims with Gird and the Schieffelins. In return, Gird would assay all of Williams' ore.

Schieffelin showed Williams rich ore from his recent Tough Nut discovery. Soon after, Williams found the Grand Central ore body. However, he did not make a joint claim notice. After a lot of argument, Williams agreed to stake off the western portion of the claim for the others, and this became the Contention claim. While the Lucky Cuss was a minor deposit, the other three became the major mines of Tombstone.

Schieffelin had been soured by the whole deal with Williams, and he felt all the best claims had now been located. Unfortunately, although the Contention was the richest, it didn't show any real promise beyond surface float, and they sold it for only $10,000 to raise much-needed capital.

News of the strike was out, and it was said that anyone with a horse, rifle and lunch could reach the area. People put up shanties and canvas tents on a barren



The Dragoon Mountains were once the refuge of the Chiricahua Apache Chief Cochise and his people. (Photo courtesy the City of Tombstone.)

ex-cattle knoll known as Goose Flats, an area that would soon become the town of Tombstone. The Cosmopolitan and Grand Hotels were built in 1879. In 1881, the Crystal Palace and 100 other licensed liquor outlets served Tombstone drinkers. Its suburbs included Hog 'Em, Gouge 'Em and Stink 'Em. Cochise County was created that year, and Tombstone's courthouse served as the county seat until Bisbee claimed the honor in 1929.

Miners from the decaying Comstock came to work 10-hour shifts for $4 a day in the new mines and mills. On the San Pedro River towns grew up around the stamp mills. The old stage road running by Schieffelin's tomb once went to the Contention Mill and City, located 10 miles northwest of Tombstone. The Grand Central Mining Co. and Fairbanks grew up where the Southern Pacific, El Paso and South Western Railroads met at the San Pedro River. Southwest of Tombstone, on the river, were the Empire and Tombstone and their mills, with nearby Millville and Charleston providing living quarters, stores and saloons for the mill workers.

Concrete foundations hidden in the tall grass are all that remain of these stamp mills, which crushed rock and amalgamated silver and gold from 1879-86. Cotton woods and willows still shade the pebble-clear San Pedro River, and yellow warblers enliven the thickets.

Art Austin, park manager for the Tombstone Courthouse State Historic Park, felt that Schieffelin might have found two major strikes in his short lifetime.

"After things settled down here, Schieffelin set off for Alaska. He sailed a steamboat up the Yukon River, but didn't find anything. He ended up in Canyonville, Oregon, where some believe he found the Red Blanket Mine. He died with some samples of high-grade silver ore."

Besides Schieffelin's rifle and an old photo of the man, the stately Tombstone Museum has ore samples that assayed 1,400 ounces silver to the ton. Other displays illustrate barbed wire styles, from Sunderland's Kink to Reynold's Necktie, and the importance of cattle companies in southeast Arizona. There are mine candle holders and carbide lamps, a complete lawyer's office and the original courtroom from the days when this building housed the county seat.

Tombstone brought thousands of miners to Arizona, and it became a supply center for ranchers in the area. Rustlers and smugglers came, as well. 'Old Man' Clanton's gang included his three sons, as well as Curly Bill and Johnny Ringo. They used the town of Charleston on the San Pedro River as their base to rob, kill and steal.

At the same time, in 1880, Wyatt Earp and his brothers James, Virgil and Morgan came to Tombstone looking for work. Some questionable stagecoach robberies linked the Clantons and Earps, and led to the O.K. Corral shootout. The townspeople felt the Earps were killers. Within the year, Virgil had been seriously wounded and crippled for life, young Morgan was dead, and Wyatt had left Tombstone under the shadow of a murder charge.

The museum has the Tombstone *Epitaph* edition of Thursday, Oct. 27, 1881. The headline reads, "Yesterday's Tragedy. Three men were hurled into eternity in the duration of a moment." A series of large panels depicts the events of the shootout.

"It's a very popular exhibit," Austin told me. He briefly recounted the courthouse's history. "We've seen over 3 million people since we opened in 1962. The building sits on the Vizina mining claim. When Tombstone got the county seat in 1881, it was required to build county offices. Lots in the center of town were expensive, so the Vizina leased the county four lots for 99 years for $1. In 1981, we discovered Arizona Parks did not own the land, though we were later able to purchase the surface rights. The patented mining claims are still owned."

Devastating fires in 1881 and 1882 caused Tombstone businesses to rebuild with adobe and brick. The two-story Schieffelin Hall was hailed as the largest non-Indian adobe building in the United States. A municipal water system was developed. Tombstone's rise in population threatened Tucson's power, and resulted in the creation of Cochise County.

Rotten Row on Fourth Street was set aside for lawyers. A Tenderloin district and a Chinese community added to the life of the town. Kindhearted Nellie Cashman ran the Russ House restaurant, helping destitute miners and raising funds for a hospital. Many of today's businesses continue the old traditions. There's Big Nose

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Too Tough/ *from page 57*

Kate's Silver Hills Trading, the Old West Cowboy Store, the Longhorn Restaurant, William Brown Holster Co., and the Bird Cage Theater.

Tombstone became a victim of its own success by producing so much silver in a relatively short time. Huge silver discoveries in the West depressed the price of silver. In addition, the mines encountered water at 500 feet and costly pumps were needed to work deeper levels. After an 1884 miners' strike for higher wages and a disastrous fire in the Grand Central in 1886, deep mining stopped. By 1890, the rustlers were dead or in prison, and the miners had moved on to the copper mines.

Mining claims were consolidated by the Tombstone Consolidated Mining and Milling Co., and from 1901 11 new pumps allowed mining to reach the 1,000 foot level. A further drop in the price of silver and saltwater in the fuel stopped the pumps. Once again, the mines closed.

Tombstone's heyday was from 1879 to 1910," Austin summarized. "Ninety five percent of the claims are now owned by the Tombstone Development Corp. They bought most of the patented claims from Phelps Dodge in the '50s. When the Hunt Brothers drove up the price of silver, it made Tombstone's dumps worth a fortune. Miners subleased from TDC and reworked the tailings by heap leaching out the silver. Then they strip mined the Contention Mine."

I drove into the hills behind town where a gravel operation was screening on the site of the old mill. After getting permission to visit the area around the important mines, I wandered through the deep pits, looking at the steep walls for signs of the mineralized faults and dikes. Ore worth $463 million in 1988 dollars was taken from the Michigan Central dike, the rich Contention-Empire tan altered zone 36 to 45 feet thick with clay, talc, quartz and red iron oxides), and the Sulphuret, Boss and Tribute dikes.

From 1980 to 1985, a rectangular open pit dug up the Contention-Empire dikes and Tranquility Fault, destroying the famous lodes Schieffelin had discovered. I stood at the sloping entrance to this excavation, trying to imagine the old mine cuts following the narrow veins 1,000 feet underground. Farther back in the hills, a few old headframes, colorful dumps, and mine openings are still reminders of this mining style.

Geologically, the Tombstone basin began as a shallow, inland sea composed of near-shore sands, muds and shells. After these were compacted and cemented into the sandstones and limestones, they were gently folded into domes or anticlines.

The cause of all the silver, galena, gold, manganese and copper minerals was probably the deeply buried Schieffelin granodiorite, a flat-lying granite that intruded the sediments about 76 million years ago. This hot magma reacted with the overlying sandstones, siltstones and limestones, baking and metamorphosing them. U.S. Geological Survey Bulletin 2042-B by Eric R. Force, written in 1996, has a detailed description and map of Tombstone's mineralization.

In the last stages of the magma emplacement, hydrothermal fluids rich in silver and other base metals found passageways into the anticlines like oil migrating into a trap. Hot magma had baked the rocks, sealing off all the exits except along the faults and cross-cutting dikes. Limestone was also reactive and provided another place for the rich fluids to form deposits. Miners followed the faults and dikes downward in narrow stopes. The roots of anticlines also yielded bonanza chambers of silver ore.

I walked down the gentle incline into the mining cut where the Grand Central, Contention and Tough Nut had been. Behind me, shots rang out from the afternoon shootout.

Tombstone found new life when former Deputy Sheriff Billy Breakenridge wrote *Helldorado* in 1928. The next year, the town held a celebration during the week around Oct. 26, when the O.K. Corral shootout had taken place. Paramount Pictures released "Tombstone, The Town Too Tough to Die" in 1942. The stereotype of a wild mining town with daily shootings and lawless behavior was born.

Ray Madzia, a full-time instructor at Fort Huachuca, lives in Tombstone and researches its history. I met him in the Chamber of Commerce where he was helping move boxes before the rooms were replastered.

"Helldorado started in 1929," he told me, wiping the sweat off his forehead. "It was the 50th anniversary celebration of Tombstone's founding in 1879. Tombstone was facing losing its county seat designation. They were trying, in part, to revive interest in the town."

Many people like Madzia enjoy the town's historic character, and they live here and commute to jobs in Sierra Vista and the high tech center Fort Huachuca.

"During the 1920s, roads were being paved across Arizona," Madzia continued. 'Many drove through Tombstone. It was on Route 80, 'the Broadway of America' as it was called then, the major roadway across the Southwest. The Bird Cage Theater was operating as a museum in the 1930s. There was interest in Indian culture. Tucson was a Mecca for health seekers. In the 1940s, Tombstone began to attract attention, partly because soldiers from the fort had lived and visited here during World War I. The Nunnelleys began to do tours of Boot Hill just after the war, and the annual Helldorado celebration started up again. In the 1950s, the TV western helped Tombstone grow exponentially as a tourist destination."

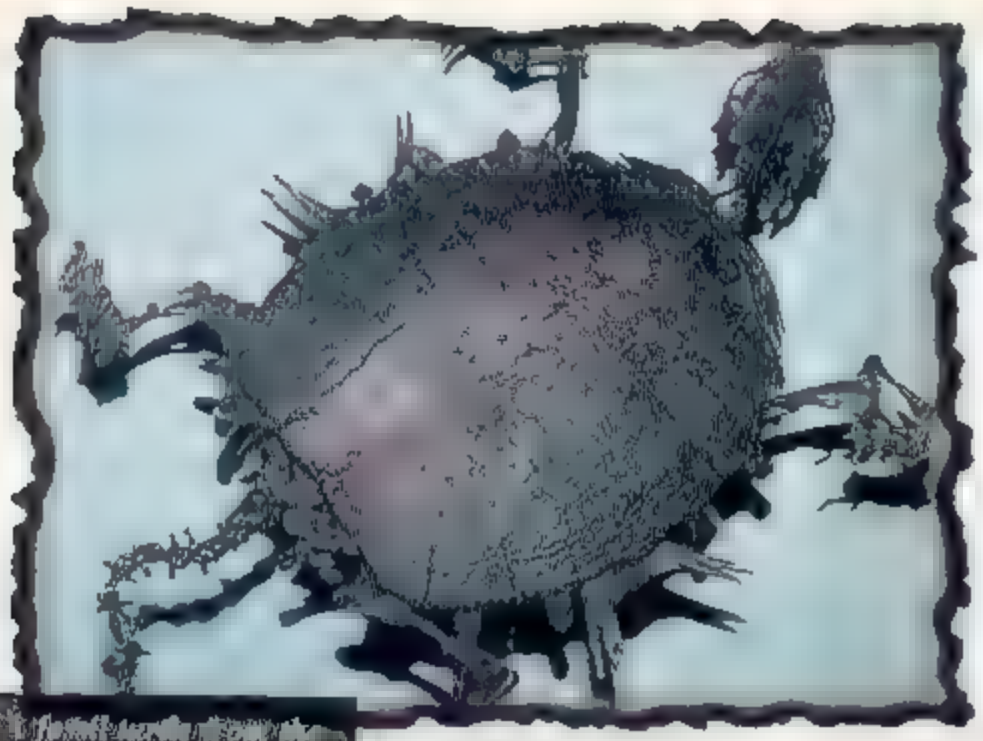
Walking on the town's shaded boardwalks, I mixed with obliging gunfighters and friendly shopkeepers. Draft horses pulled stagecoaches and covered wagons used for tours. Across and down the street from the Courthouse Museum, the Rose Tree Inn Museum pays tribute to a pioneering family that settled here in 1880. Original furniture freighted from Leadville, Colorado, chunks of rich silver ore, maps of the ore bodies and mines, and in a courtyard, the extensive rose tree dating to 1885 make up some of the displays.

A cowboy selling tickets to the stagecoach enthusiastically told me about the upcoming Helldorado.

"It's a three-day event: gun shooting on horseback, a carnival, street skits, a vigilante reenactment. I used to come down here from Phoenix as a kid." He smiled at the memory. "It's a great place for kids, and for people who like westerns."

Schieffelin would probably enjoy this recreation of the old town, I thought. Then I headed back out into the hills to look at the rocks once more. ◆

The shootout at the O.K. Corral is one of the best-known tales about this mining town. (Photo courtesy the City of Tombstone)



A fossil turtle from the Middle Eocene lake at Messel, with many small bones preserved. (Photo by the author)

A cast of an original Triceratops elatus from the Lance Formation in Montana.

Germany's FOSSIL Showcase

The ornate 19th-century pink stone facade of the Naturmuseum Senckenberg is often mistaken for a palace by tourists.

Marking Time at Frankfurt's Natural History Museum

by Murray Eiland

Near the city center of Frankfurt, Germany—regarded as the financial heart of Central Europe—there is a surprising sight. Amidst an accumulation of modern skyscrapers and office buildings, hastily constructed in the wake of war damage, there stands an ornate 19th-century edifice that suggests that, on this patch of ground at least, time has stood still for at least 100 years.

Constructed of pink stone with aging copper ornaments on the facade, the building is often mistaken for a palace by tourists. Many locals make pilgrimage here, particularly on the weekends. Several times, while walking down the street, I have been nearly run down by cars filled with children. A single word catches my ear: dinosaurs. Even without knowing the name of this building, there is only one place in Frankfurt it could be: the Senckenberg Museum.

While the museum has a wide range of natural history exhibits, from stuffed animals through minerals, the pride of place must be with the giant lizards. There are full-sized models, as well as rare vertebrate fossils, many of them from America. Of particular interest is a room with a variety of elephant skeletons, fossil and modern. Frankfurt has every right to be proud of this museum, which not surprisingly was the darling of some of its greatest residents.

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Fossil Showcase/ *from page 48*

In 1815 the well known poet and amateur scientist Johann Wolfgang von Goethe expressed his interest in seeing the citizens erect a museum devoted to natural history. At that time, Europe was possessed by novelty and the leisured classes devoted themselves to collecting and studying natural rarities. Acting quickly to gain prestige for the rapidly growing city, the citizens founded the Senckenberg Nature Research Society in 1817, naming it after Dr. Johann Christian Senckenberg (1707-1772), a famous physician with a great interest in natural history. In 1821, the museum was opened. Because there was no university in Frankfurt yet, the institution played a vital role in coordinating research activity, as well as systematically collecting specimens, in all branches of natural science.

In 1907 the museum moved to its present location. Very soon it was regarded as a major center of research, and in 1912 the theory of continental drift (which explained how the continents fit together in the distant past) was presented to the public for the first time by Alfred Wegener. In 1914, the museum was transferred to the newly founded Goethe University in Frankfurt. While the building was badly damaged during World War II, the collections were safely stored outside the city. In 1946 reconstruction began.

Since about 1975 there has been a special interest in paleontology in the town. The museum has been excavating the former oil pit of Messel near Darmstadt. This ancient lake, dating to the Middle Eocene (50 million years ago), has yielded a massive array of fossils. Skin, pelts and plumage are often found preserved. The fossilized animals and plants attest to a tropical climate. A good example is the horse *Propalaeotherium hassiacum*, that is so well articulated it appears to be running. It has a height from the shoulder of about 60 cm. The preservation of this fossil is stunning, as there is only a small amount of crushing. Besides bones, however, this fossil preserves aspects of the soft tissues, as well as the stomach contents. While there have been many heated debates in academic conferences about what coprolite belongs to which species, at times backed up by hypotheses using gastric stones, there is no replacement for finding the dead animal with its last meal intact! A number of stunning fossils from this site are on display, and near the museum a former factory was restored to provide space for a research institute devoted to geology, paleontology and paleobotany.

Even the exhibits placed on the outside of the museum give some foreshadowing of the contents. South of the entrance are a group of tree trunks recovered from Saxony and Thuringia dating to the Permian

Age (250 million years ago) On the other side of the entrance is a group of hexagonal basalt pillars about 15 million years old Near the entrance is a cast of a giant ammonite shell. What waits within is of an entirely different magnitude, and because there is a maze of rooms, it is a good idea to purchase a guidebook with a map Luckily, guidebooks are available in English.

Both for scientific and "artistic" merit, the sea lily (*Seirocrinus*) slab is given pride of place It is stunning for the preservation of fine detail, which is brought out by fabulous preparation. For anyone who has picked over trays of disarticulated material in shows, this will be a most welcome display. Also in the entry hall is the crocodile *Steneosaurus* This animal was adapted to a marine existence and bore particularly short front legs that would barely allow it to walk on land The oil shales at Holzmaden that preserved the animal were deposited far from any contemporary sea coast While it may have lived in coastal areas, after death the creature would have bloated with gases of decomposition and been swept out to sea The deep-ocean environment, low in oxygen, would have preserved much of the tissue present in the fossil. In life, the crocodile had to lay eggs on land, and the flinty gastric stone (which is still found in crocodiles today) was likely obtained while on a terrestrial foray

There are also a number of ichthyosaurs on display, lining the walls of the room They are all of the genus *Stenopterygius*, coming from the Lower Jurassic (Liassic) shales of the Holzmaden region Like the crocodile, they are exceptionally preserved Most of them have not experienced extreme transport in currents that would have disarticulated the skeletons In many cases, soft parts of the body, such as skin, have survived Ichthyosaurs are an extreme representation of adaptation

The clearest case for this adaptation on display is the specimen of *Stenopterygius*, the outline of whose body is visible The fins are also clear, and not all of them were supported by bones The dorsal fin and the upper fluke of the tail fin were supported by stiff tissue alone These creatures were fast swimmers, comparable to modern dolphins, and not surprisingly, studies of their modern counterparts provide the most convincing analogs. Like dolphins, the *Stenopterygius* was no doubt covered by a layer of fat that would flex enough to allow the animal to slide through the water In essence, the muscles activated a bow, made of soft tissue, that propelled the animal forward The fins acted as stabilizers (like the tail of a rocket) and steered the body, which was driven by the tail. Like a dolphin, there was little chance that the head would move relative to the trunk, as the neck vertebrae are short and stiff It is possible that the bone core of the lower fluke of the tail (from the terminal section of the backbone) enabled the creature to rise rapidly to the surface of the water where it could breathe

A cast of the famous Mühldorf mastodon, Gomphotherium angustidens, the original of which is in Munich

A real strength of the museum is the room devoted to the evolution of elephants. There are displays of both fossil animals and their modern relatives, including sea cows and the small hyrax, which looks something like a marmot It is quite interesting to see how these modern animals evolved from a basal ancestor dating to the Oligocene in Egypt. Quite clearly, the major modern feature of elephants is the development of the upper lip and nose and the long tusks. One 24-meter-long wall is devoted to presenting the evidence, and there is an excellent presentation on the evolution of proboscideans, the zygodonts with crushing teeth and bunodont (having low conical cusps) grinding teeth with lamellar grinding surfaces

The mastodons spread from Africa in the Neogene, about 25 million years ago, and eventually dominated Eurasia and America There was a later migratory wave of modern mastodons in the Pleistocene, about 2 million years ago The so-called Mühldorf mastodon (*Gomphotherium*) is one of the bunodont mastodons, and is represented in the museum by a cast of the oldest and largest not to mention most complete exhibited skeleton. The original is kept in the Bavarian State Collection in Munich It was discovered in Miocene river sands on the banks of the Inn, south of Mühldorf, in 1971, and is about 10 million years old. It has a long, low set skull with four tusks in all, two in the upper and two in the lower jaw This simple structure of its molars makes the *Gomphotherium* a primitive (nonspecialized) proboscidean

At the other end of the scale is the dwarf mastodon During the Ice Age, dwarf forms of large mammals developed on islands in the Mediterranean The restricted living space and limited food supply played critical roles in this development. On the other hand, some small species grew to giant size in a relative paradise with a lack of predators and/or the occupation of niches that had become vacant A fully grown pair and the skull of a young animal come from deposits in a cave near Spinagallo, Sicily, and are about 70,000 years old In another section, there is an excellent "dinosaur mummy" (now dissected) from Wyoming. It has a nearly complete skeleton, as well as a very rare preserved impression of the skin and the horny beak

A particularly important specimen is the *Placodus* Apart from the skeleton on display, only isolated bones, skulls and teeth of placodonts have come to light. The animal replaced its dentition throughout its life, and teeth are some of the most durable parts of animals, as the hard layers of bone and enamel resist decay As a result, teeth are found fairly commonly Placodont teeth were particularly robust and enabled the animals to feed on shelled animals. They captured them, or tore them loose, with their incisor teeth and used their flat-crowned cheek and palatal teeth to open them

The story of the discovery of the only known placodont skeleton is an exciting one It was first recognized by miners after the enclosing limestone had been broken down. The individual fragments were patiently sought in stockpiled material and stuck together The skeleton was then prepared out one side at a time, and the whole specimen was finally ready for mounting

It is quite easy to reach the museum The S Bahn lines S3, S4, S5 and S6 lead to the Westbahnhof station, from which it is about a 10-minute walk to the museum Taking the U-Bahn, the method of travel if you are inside the city, lines U 6 and U7 lead to the station Bockenheimer Warte, and then it is a three-minute walk The newly completed line from the central station, where one would arrive from the airport, is U4 to the Bockenheimer Warte station The museum is open daily 9-5, Wednesday 9-8, Saturday and Sunday 9 6 It is closed on Good Friday, Dec 24 and 31, and Jan. 1. Admission is 7DM for adults, 3DM for ages 6-18 For more information, contact Naturmuseum Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main, phone 069 / 7542-0; fax 069 / 746238

The Many Varieties of Feldspar

Part I

Himalaya Mine elbaites in white albite (Pala International). (Photos by the author)

This Group of Minerals Takes on Numerous Forms

by Bob Jones

If you want to have some fun with your geologist friday, ask him whether quartz or feldspar is the most common mineral. Of course, this is a loaded question. You see, quartz is a single rock species, although you could argue that there are all sorts of varieties—agate, chalcedony, crystals, etc. Silicon is considered one mineral because in any of its forms it is still silicon dioxide. So if your friend chose quartz, he was right.

Feldspar, often considered the most common mineral, is in reality a group of minerals; there is no one chemical combination called feldspar. Feldspar can be a sodium aluminum silicate or a calcium aluminum silicate, a mixture of sodium and calcium aluminum silicate, or a potassium aluminum silicate. So why group these minerals under one name? It's because they are closely related in composition and crystal structure. In addition, they may be found in similar occurrences and with similar properties. The best reason to consider them different species and not a single species is that the feldspars can show two distinctly different crystal forms, monoclinic or triclinic. The other reason is that they show varying chemical compositions.

continued on next page

Feldspar/ *from page 65*

All the members of the potassium or orthoclase feldspars are potassium aluminum silicates. The other feldspars are not so simple to identify chemically. Instead, they form a series ranging from more or less pure sodium aluminum silicate (albite) to almost pure calcium aluminum silicate (anorthite) and are called the plagioclase feldspars.

Because the sodium and calcium atoms can easily substitute for each other in the formation of a feldspar, a continuous series of combinations forms as a result of this mixing. This leads to several varieties, each with a recognizable set of properties. Add to that the fact that these feldspars can actually occur side by side, and confusion reigns. They may even mix in the same crystal. No wonder you can be confused by a single specimen. Having more than one member of the series in a single crystal form can also lead to additional variety names. Cleavelandite, common in some pegmatite deposits, is a mix of albite and oligoclase.

Most collectors do not seek out feldspar minerals to enhance their collections. Feldspar is most important as a rock forming mineral. Yet there are a few feldspars, like amazonite, that are desirable. And there are the gem varieties, which are very important to the lapidary. Many feldspars show perfect textbook crystal form. There are also interesting twinning forms, but most often they occur as drab white masses, frequently found embedded in and part of a host rock. Most are hardly spectacular. Yet, the real student collectors and serious collectors gain great joy from the several members of the feldspar group — albite, oligoclase, andesine, labradorite, bytownite, anorthite, peristerite, pericline and aventurine feldspar. You immediately recognize that there are some gems on this list, labradorite being the most common. So the feldspar group offers to both mineral collector and lapidary something to study and enjoy.

There are well over a dozen members within the orthoclase (potassium) group and the plagioclase, or albite/calcium, group altogether. There are six main species in the entire feldspar family. They are albite, anorthite, andesine, bytownite, labradorite and oligoclase. These six show a triclinic crystal form and are separated by that crystal form from the orthoclase group, which is monoclinic. Those showing the triclinic form, including their varieties, are oligoclase, aventurine feldspar, andesine, labradorite, bytownite, anorthite and peristerite. This article will treat only these members of the plagioclase, or sodium-calcium group, sometimes called the soda lime group. A subsequent article will address all those members of the orthoclase group.

The most commonly seen member of the plagioclase group these days is albite, a sodium aluminum silicate. This is the snow white, water thin mineral often found associated with the gem crystals tourmaline and beryl from gem rich granite pegmatites. Since pegmatites are one of the world's great sources of gem crystals, it is only natural that they are worked diligently. And such diligence inevitably produces wonderful accessory minerals like albite. The pegmatites of Brazil were in previous years, and still are, a marvelous and most important source of these feldspar accessories. The most interesting minerals from this location are the heavily etched feldspars, which may form a superb matrix for the more stable gem minerals.

The pegmatites around Mesa Grande and Pala in San Diego County, California, have also produced marvelous gem crystals associated with snow white albite. The albite is usually called cleavelandite, though that name has been discredited and appears only in the older literature. Currently, the finest examples of albite come from Pakistan. That country's rich pegmatites produce superb gem tourmalines with a skirt of water thin albite. This provides a superb setting for the colorful gem.

Oligoclase, in its most common form, tends to be rather uninteresting unless you enjoy studying crystal twinning. It tends to be a chalky white to reddish color when in opaque form, but it can be a very exciting gem mineral when it is found in bright yellow, gem clear crystals, as it is in Madagascar and Brazil. These are very rare occurrences. In that form, of course, oligoclase is an exciting gem and much sought after, which suggests that it is pricey.

Bytownite can also be gemmy, so closely resembling labradorite in composition that the two are easily confused. Fine, clear, pale yellow masses of this mineral were easily collected from the surface of the weathered volcanic Pinacate formations in southern Arizona.

Another plagioclase feldspar that is an exciting gem can still be collected in Oregon. It is an oligoclase, variety aventurine, usually called sunstone in its gem form. One important characteristic makes it very desirable. It can be filled with metallic, platy inclusions, which give it a very sparkly look, hence the aventurine label. If the included metallic particles are hematite, or in one case copper, a fine red flash is seen. Sources of sunstone include Tanzania, Brazil, Russia, India and Oregon. In each case, the host rock is a form of volcanic rock. An interesting aspect of the Oregon sunstone is that its unusual reddish color is due to microscopic copper inclusions. In spite of the included microscopic copper, the Oregon gem is totally transparent.

It should be noted here that the term "aventurine" is also applied to a variety of quartz with metallic inclusions which give it a sparkly appearance. There is even a coppery type of glass that sparkles and is sometimes called aventurine glass. Several types of feldspar in the soda lime group show some sort of flash or sparkle.

Then there are the little known feldspar varieties like peristerite that have an odd, flashy appearance that often shows a subdued or faint rainbow effect. This comes from their internal twinning structure. Called "lamellar twinning," it results when water thin plates of albite alternate in opposite directions within a single crystal. This is called "polysynthetic twinning." These platy crystals can be so thin that they cause a near schiller effect and can be easily seen as delicate parallel lines or striations. This is particularly prominent in the feldspar called peristerite, or pigeon stone, found in Ontario, Canada. This makes for an unusual gemstone that is not readily available these days.

Anorthite, the calcium aluminum silicate member of this series, does not produce gem varieties. It is perhaps best described as the forgotten member of the group. It has only been found as discrete crystals in a couple of places. Mount Vesuvius being one classic source. Its crystals occur in tiny, sharp phenocrysts in volcanic rock. Japan has also produced distinct crystals.

If there is a regal member of this sodium-calcium aluminum silicate group, it has to be labradorite. Though royalty is supposed to be very limited in number, labradorite is abundant by comparison. What makes labradorite so special is its wonderful flash of color, especially from a polished surface. Scientists call it a "schiller effect." Labradorite is very well known as a gem material that shows a bright play of colors, mainly blues and greens. The ground mass is most often a delicate gray. The flashing colors are bronze, yellow, reds and purples. This distinct play of colors has been given the name "labradorescence."

Huge masses of this richly colorful feldspar have been found in upper New York State. During the construction of Interstate 87 in the Warren County area, not far from the more noted almandine garnet sources around Gore Mountain, large blocks of this colorful mineral were unearthed and could be found along the roadside.

The far Siberian reaches of Russia boast of superb labradorite. It has been collected in masses large enough to be cut into huge curbstone blocks, which can be seen throughout the interior of the Kremlin as decorative borders to huge flower beds. Wonderful blocks of Siberian labradorite can also be seen in the GEMS Museum, officially called the Colored Stone Museum of the Department of Natural Resources, in Moscow. Other known sources of labradorite include Mexico and Madagascar.

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Feldspar/ *from page 66*

You might have guessed from the name that Labrador, that cold Canadian province, is a source of this lovely stone. Brilliant bronzes, blues, greens, reds and golds are the hallmarks of this source. Labrador's namesake gem is found as entire rock formations near Nain, on the island's coast. There are other deposits on the island that have yielded fine labradorite, often seen as exceptionally large, flat, lathlike structures. The colors flash as a piece is rotated in bright light. In most cases, these "panels" of color are small, but some of the most spectacular pieces may flash a brilliant color that spans 24 inches across without further rotation.

While Labrador has become famous for its very flashy namesake rock, perhaps the most colorful labradorite comes from Finland. It is so brilliant, it has been given a special name, spectrolite. The pieces I've seen are superb, but do not surpass by a quantum factor the best from Labrador.

There is yet another type of labradorite, in addition to the yellow and red gem material from Mexico and Oregon. This odd material is called "black moonstone." It is actually dark blue due to some form of needlelike inclusion, and does not create much of a stir in the world of gems.

Maybe the most unusual—certainly one of the most prolific—deposits of labradorite I've ever seen is a gem-rich volcanic flow in a very remote part of the Chihuahua desert. A small amount of this bright material in faceted form came out a few years ago and was tentatively identified as bytownite. Further study at the Smithsonian determined the crystals to be labradorite.

I had the good fortune to be guided into this amazing gem deposit by my friends Benny and Elva Lenn, who found the deposit after a long and arduous search. The search commenced when Benny found one small fragment of yellow gem labradorite while on a hunting trip. What he eventually found was a huge basaltic flow of rock shot through with phenocrysts of yellow gem labradorite. As the basalt weathered, the labradorite survived, often fragmented, but part of the detritus on the volcanic slopes.

A walk over the slopes of the flow and the fresh dump revealed thrilling quantities of the yellow gem. In just an hour's time we picked up a large quantity of rough. The basalt ledge was shot through with large glassy crystal sections, many of them suitable for faceting. I estimated that the gem content of the rock was as high as 40 percent in some areas. Some of those phenocrysts were up to 2 inches across, though most showed stress fractures. Even so, there was plenty of good, clear gem rough. It was fun to actually be choosy over which crystal fragments to pick up and keep.

The flow hosting all that labradorite is very badly weathered. It is 14 feet thick where it has been exposed by mining activities. Most of that exposed rock is crumbly and loose. It extends at least 200 yards exposed, but traces of labradorite can be found on the slopes farther up the hill. There are even fragments found as float on the surface of the opposite side of the hill, suggesting that perhaps the original lava flow underlies the entire formation. Estimating the amount of gem rough here would be a futile exercise. Suffice it to say there is enough gem rough to satisfy the market, and then some.

It is not surprising that varieties of feldspar are found all over the place. Superb albite and other feldspar crystals are found in pegmatites associated with exciting and valuable gem crystals. It is also found associated with, and part of, metamorphic rocks. After all, it is a rock-forming mineral, and as a group it is the most common of minerals.

Of all the world-wide deposits and occurrences of feldspar, the ones you would perhaps fail to think of produce virtually no crystals or solid rocks. These are the white clay deposits found in western England, France and elsewhere. When found pure, it is called "china clay," and is an important raw material. When fired, it makes some of the most superb snow-white dishes and other porcelain objects in our china cabinets.

To appreciate this abundant and very functional material, you have to understand how it develops. Granite, the rock of which the earth's continents are made, is composed mainly of quartz and feldspar. Sure, there are all sorts of accessory minerals—mica and the like—but quartz and feldspar make up the vast bulk of the continental rocks. When weathering attacks granite, the feldspar readily begins to decompose. The quartz is much more resistant to weathering, so when the feldspar breaks down, the quartz grains are released and carried away by moving water. Eventually, the feldspar forms clay, a very fine-grained material in such tiny flakes that it can be carried greater distances than quartz grains. This results in a natural segregation of clay and quartz. We call the clay "mud" when it is wet, and in most deposits it is useless, with all sorts of impurities. But in rare cases, the clay may develop from feldspar that is virtually pure and snow-white. Such was the case in Cornwall. In that very unusual case, the deposit is considered precious ore and is mined for pottery. Very famous china, such as Wedgewood, has been made with clay from the Cornish deposits. When the clay is reddish, it may end up being used for bricks or pottery.

The sheer quantity of feldspar varieties means there's something for every collector. But whether in collectible form or not, plagioclase feldspars are important minerals with which all rockhounds should be familiar.

Rock Science

by Steve Voynick

The Fundamentals of Fire Assay

by Steve Voynick

Everyone who has explored old gold and silver mining districts has seen scattered charcoal, fire brick, cupels and crucible fragments, and other telltale reminders of the offices and shacks where the assays were used to determine ore grades.

Fire assays, the oldest, most reliable and, until recently, the fastest method of determining gold and silver ore grades, are specialized quantitative procedures in which fusion separates precious metals from carefully weighed ore samples. The fusion, or melt, is performed at high temperatures, hence the term "fire assay." Until electric furnaces became available, assayers smelted ore samples in drafted charcoal furnaces.

Fire assays begin with the selection, crushing, grinding and weighing of ore samples. The powdered samples, usually weighing at least an ounce, are placed into ceramic crucibles and mixed with an assortment of dry chemicals, including lead oxide, a reducing agent such as charcoal, sulfur, flour, sugar or any powdered material capable of combustion, and a flux such as silica sand, borax or fluorite to remove impurities.

The assayer places the crucibles and their mixed contents into a furnace at 1,900 degrees F. As the reducing agent burns, it reduces the lead oxide to metallic lead and any silver minerals to metallic silver. The lead, present as tiny droplets, collects all the gold and silver present.

After removing the crucibles from the furnace, the assayer thoroughly mixes the molten contents, then pours them into cone-shaped molds. The molten lead, containing any gold and silver present, sinks to the bottom of the mold, while the gangue, or waste portion of the ore, and the fluxes form a floating, glassy slag.

After cooling and solidification, the assayer separates the slag from the metallic lead "buttons" at the bottom of the molds. He cleans the buttons and places each into a cupel, a small dish made of finely ground bone ash and shaped like a short vertical cylinder with a deep concavity.

The cupels go into a well-drafted "cupelling furnace" heated to 1,750 degrees. Heated bone ash cupels are able to quickly and completely absorb metallic oxides. The melting lead converts to lead oxide, which the bone ash cupels immediately absorb. Any gold or silver present does not oxidize, but instead concentrates until the last of the lead is absorbed, leaving behind only tiny beads, called dore beads, in the bottom of the cupel.

These beads, which now contain all the precious metals present in the original samples, are carefully weighed on a microbalance. Next, the assayer places the beads in hot nitric acid to dissolve the silver without affecting the gold. Finally, the assayer weighs the remaining bit of gold. The difference between the gold weight and the weight of the original dore beads represents the weight of the silver.

Knowing the exact weight of the original ore samples, the assayer then converts the gold and silver weights to ore grades, expressed as troy ounces per standard ton or as grams per metric ton.

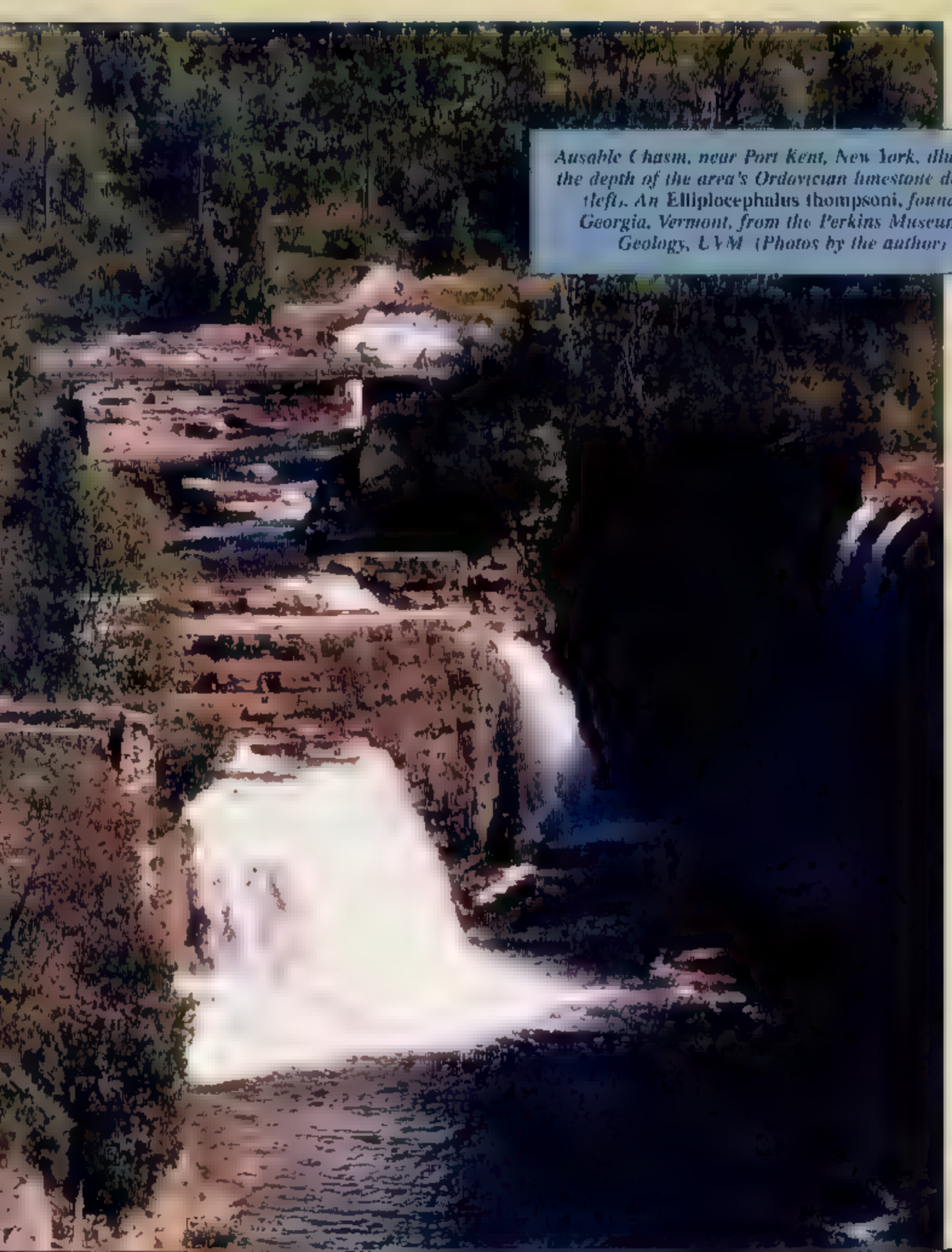
Today, high-tech analytical methods are slowly displacing traditional fire assays in many gold-mine operations, at least for part of the process. In modern lab procedures, the dore beads are dissolved entirely in hot aqua regia (a nitric-hydrochloric acid mixture, which can dissolve gold), then analyzed qualitatively and quantitatively by atomic absorption spectrometry. Some assay labs rely on neutron activation analysis methods, which are much faster, with accuracy equal to that of fire assay methods.

Fire assaying is a science and an art that demands impeccable laboratory technique and the ability to assure that original samples are truly representative of the ore. The latter can be a difficult job, especially when gold values are not evenly disseminated throughout the ore.

Although fire assays in their present form evolved more than 150 years ago, they continue to play an important role in mineral analysis. For whenever modern gold-ore assayers question the results of their high-tech spectrometry and neutron-activation analytical methods, they still turn to one thing for confirmation: the old, reliable fire assay.

The Fossils of LAKE CHAMPLAIN

Collecting Marine Fossils on the New York-Vermont Border



Ausable Chasm, near Port Kent, New York, illustrates the depth of the area's Ordovician limestone deposits (left). An Elliptocephalus thompsoni, *found in Georgia, Vermont, from the Perkins Museum of Geology, UVM. (Photos by the author)*

by Ken Aiken

At 90 feet the water is cold and black as midnight. Sediment swirls up from a careless kick and temporarily obscures the beam of my dive light. A few feet away the bottom angles into the unknown depths, but beneath me in the small pool of yellow light I can see the angular blocks that identify my destination. Far from any ocean, in the landlocked state of Vermont, I'm scuba diving on the oldest known coral reef in the world.

Four hundred and fifty million years ago, the water wasn't fresh and this site was located on an expansive continental shelf in the tropics. Life teemed in these fertile waters: sea lilies (crinoids), sponges (Porifera), colonies of mosslike animals (Bryozoans), shellfish (Brachiopods), worms, trilobites (Arthropods), nautiloids (Cephalopods), and more—millions of years before the first crude plants established themselves on land, and tens of millions of years before the first amphibian appeared. These aquatic creatures lived during a period so old-stark that the giant

dinosaurs of the Jurassic Period lived closer to our own time than to theirs. But evi-

dence of their existence is written in stone (so to speak), and defines the region known as the Champlain Valley.

The boundary between upper New York state and Vermont is an imaginary line dissecting the sixth-largest lake in the United States. Lake Champlain, 107 miles long and 12 miles across at its widest point, with over 600 miles of shoreline, encompasses 490 square miles and contains 80 islands. The lake is a remnant of a much larger inland sea, one that stretched from the Adirondacks to the Green Mountains at the closing of the Pleistocene Epoch (the Age of Glaciation), some 10,000 years ago. Today the valley, which was once the bottom of this inland sea, is the richest agricultural land in the state, and its natural beauty has encouraged residential development along the lakeshore during the past three decades, especially in the vicinities of Plattsburg and Burlington.

Unlike the rest of Vermont, which is composed of metamorphic and igneous bedrock, the geology of the Champlain Valley is primarily sedimentary limestone from the Ordovician Period. Combined with Precambrian rocks and Cambrian sandstones, the valley provides a record of the beginning of life on this planet. The Ordovician limestones are especially rich in fossils, so much so that particular ones are used to identify and date specific types of these sedimentary rocks. It is logical to assume that older layers of rocks would be found underneath the younger ones, but due to the complexities of plate tectonics and continental drift, a maze of ancient fault lines and overthrusts have disrupted the geological sequence. The Taconian mountain building cycle, which took place between 445 million and 435 million years ago, and the Acadian cycle of 375 million to 335 million years ago, created the modern Adirondacks and Green Mountains. This mountain building was also responsible for forcing layers of older rocks over deposits of younger sedimentary deposits and for tilting the once level strata. Several hundred million years of wind and water erosion and a million years of glacial activity have removed millions of years' worth of sedimentary deposits, sculpting the landscape of the region into its present contours and leaving exposed the ancient rocks that contain these coral reefs.

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Vreloboia Iwarthus beckii (top) from the Stony Point Formation on North Hero Island and a crinoid bottom, in Glens Falls limestone from the author's collection. Tilted beds of Glens Falls limestone (right) on the beach at D.A.R. State Park.

Lake Champlain/ *from page 73*

Aside from the dark and the cold, there are other obstacles to searching for fossils on Colchester Reef, the limited amount of time a diver can remain at depth, and the density of an aquatic atmosphere that makes work with a hammer and chisel resemble a dream in which every movement is in slow motion. Fortunately for me, not all of these Ordovician reefs are submerged beneath the frigid waters of the lake. From Whitehall in the south to Quebec in the north, there are over 600 miles of shoreline, and most of it is exposed limestone.

Finding fossils is not difficult, it's obtaining access to private land and permission to collect specimens that often proves to be the major obstacle. But those who are willing to either seek permission or restrict themselves to taking pictures will be richly rewarded at several of my favorite sites. There are numerous old quarries located across the entire Champlain Valley. Limestone used to be commercially important as a building material, for the production of quicklime (plaster), and as a natural alkaline to reduce the acidity of agricultural land in other parts of the state. Finding and gaining access to these private quarries is the goal of any serious paleontologist or collector.

On the southern end of the lake, the Champlain Bridge spans the narrows between Crown Point, New York, and Chimney Point, Vermont. Both points are state historic sites, and both show that the earliest settlers used the fossiliferous limestone to construct the foundations and fortified walls of their buildings. Underneath the bridge on the Vermont side and along the shore just north of the bridge is a site I visit repeatedly. (Please obtain permission from the owners who live in the house opposite the historic site, before entering.) This is, by no coincidence, Crown Point limestone, part of what geologists called the Chazy Group in the chronological division of these Middle Ordovician sedimentary deposits. Here are found bivalve shells, rings of sponges, tiny corallike branches of Bryozoa, spiral nautiloids and, of course, trilobites.

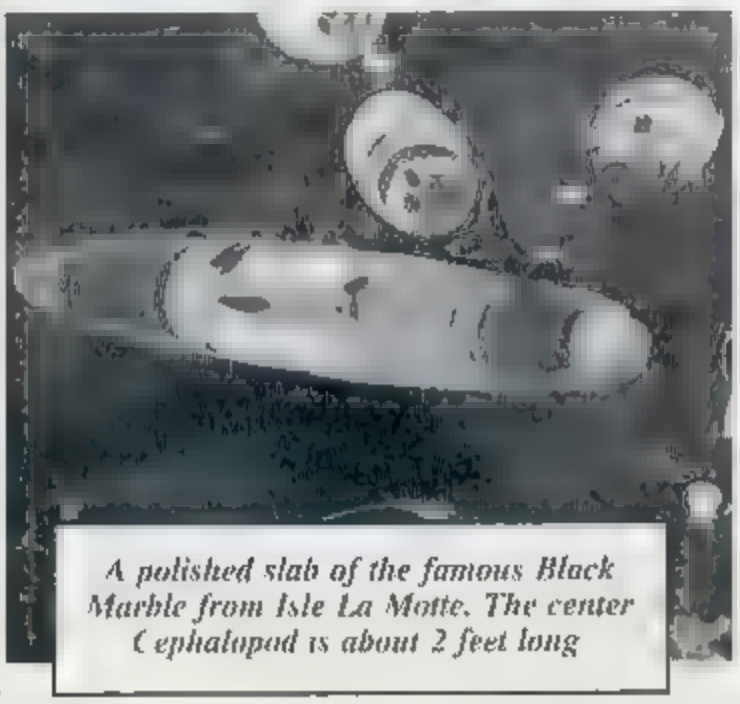
One of the finest exposures of Glens Falls limestone in the region is located just a mile and a half north of the Champlain Bridge in the D.A.R. State Park. Here the slanted bedding planes form the "beach" of the state park, with those to the south being older than those to the north. Visitors who take the time to examine the lumps and bumps in the dark gray rock will discover that these are fossil Bryozoans called *Prasopora*. The beading layers on the southern end of the park are especially worthy of study, and one can find plenty of fossils in rocks that have been exposed and broken by natural erosion. Fossil collecting is prohibited in the state parks to discourage the destruction that generally accompanies it, but there's no rule against photographing and studying the specimens.

On my last trip to the park, the water level of the lake was extremely high, so high that I had to make my way through dense underbrush to reach a favorite location. Since I'd last visited, erosion had broken a large slab from the cliff and weathered the surface. The surfaces of these bedding planes were as rich as any paleontologist could ask for. I discovered the tail (pygidium) of a *Flexicalymene* trilobite, Brachiopods galore and—a first for me at this location—several small sea lilies or crinoids (Echinodermata), probably *Dendrocrinus alternatus*. But I'm a trilobite fan, and the D.A.R. State Park is the place to look for *Cryptolithus tesselatus*.

I've found many a choice segment of this small Ordovician trilobite, but have yet to see a complete specimen. The shapes of remains in the dense conglomerate of some bedding planes make it difficult to distinguish fragments that suggest a treasure lying under a microthin layer of sedimentary limestone. In fact, I wouldn't have recognized one particular shape if *Trilobites: Eyewitness to Evolution*, by Richard Fortey, hadn't been part of my winter reading. What I think I found is a small, complete *Cryptolithus tesselatus* on its back showing all its legs.

Button Bay and Kingsland Bay state parks are two other prime locations for paleontological study, and fossils are found along almost the entire shoreline south of Shelburne. But there is an island on this beautiful lake that is marked with an X on the maps of world-renowned paleontologists and biopaleontologists. Lying to the north near the 45th parallel, it is known as Isle La Motte.

The major islands of Lake Champlain lie north of Burlington: South Hero, North Hero, Valcour and Isle La Motte. U.S. Highway 2 travels north from Burlington, crosses the lake on the Sandbar causeway, then runs through South Hero, North Hero and Alburg to the bridge crossing at Rouses Point, New York, on the Canadian border. The township of Alburg—one of only two places in the continental United States not connected to land within our borders—feels more like an island than a long peninsula. State Route 129 junctions at U.S. Highway 2 immediately after the bridge crossing from North Hero to Alburg. A

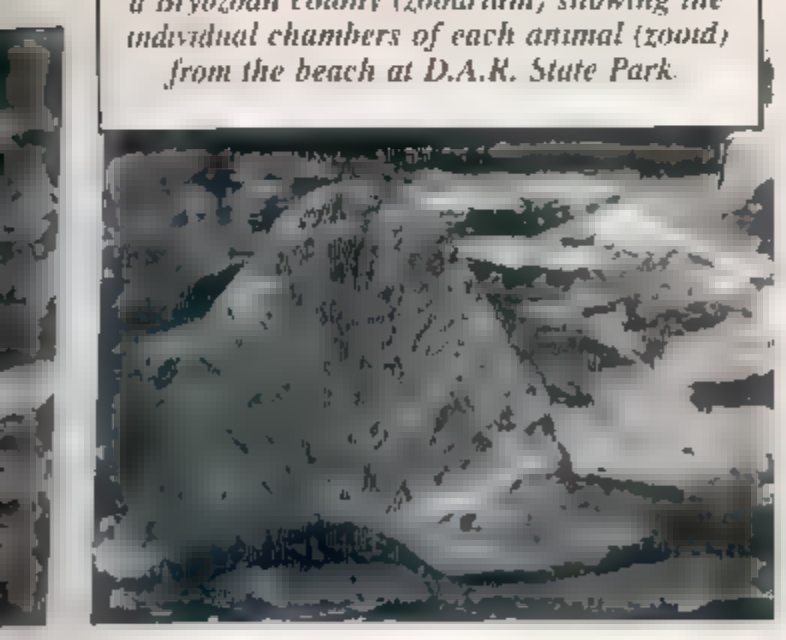


A polished slab of the famous Black Marble from Isle La Motte. The center Cephalopod is about 2 feet long

dead end highway, it crosses the lower peninsula and over a short causeway onto Isle La Motte

When the famous French explorer Samuel de Champlain set forth from Montreal in 1609 to explore the legendary lake described by the Algonquins, the first place he landed and made camp was on Isle La Motte. The French recognized the military importance of the lake and established the first settlement in Vermont at this site in 1666, the building of Fort St. Anne became the first recorded use of the island's limestone as a building material. The first commercial quarry in the state was established at this site in 1761, and by 1850 the stone was being quarried and shipped (via the Champlain Canal to the Hudson River) all over the eastern United States and Canada. If you've gazed at the Brooklyn Bridge, the Victoria Bridge in Montreal, the facade of Radio City Music Hall, or the U.S. Capitol building, you've seen the famous Chazy limestone from Isle La Motte.

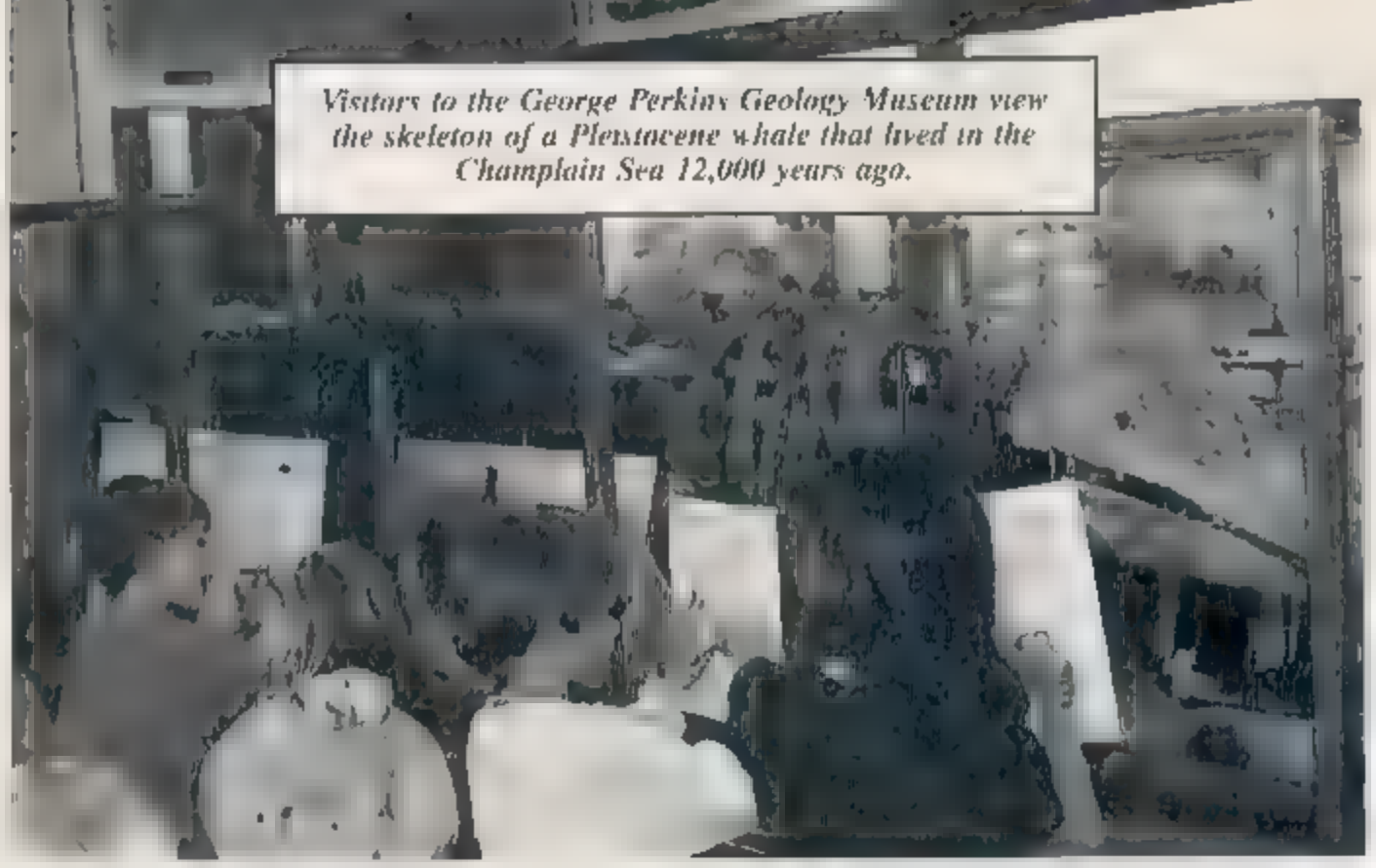
Lying in bands angled roughly southwest to northeast, the bedrock geology of the island progresses in an orderly fashion from the oldest rocks on the southern shore to the youngest on the northern one. The three limestones of the Chazy Group (Day Point, Crown Point and Valcour) dominate the southern half of the island, and their outcroppings are the famous Chazyan Reefs -the oldest coral reefs in the world. My favorite collecting spot is the Fisk Quarry on the southwestern shore, the very place from which came the gray blocks of



a Bryozoan colony (zooarium, showing the individual chambers of each animal (zooid) from the beach at D.A.R. State Park.

Crown Point Limestone used in those, and many other, grand edifices.

I like to bring people here, allow them to wander about, then point out that the rock they are walking on is filled with palm-size *Maclurites magnus*, a large gastropod often mistaken for an ancient nautiloid (a Cephalopod). In the spring, after the most exposed ones are loosened by a season of freezing and thawing water, they often can be popped from the bedrock using nothing more than a knife. While these are the most dramatic fossils found at this site, patient examination soon shows a wealth of tiny forms: stromatoporoid and alga mounds, Brachiopods, Bryozoans, Pelmatozoans,



Visitors to the George Perkins Geology Museum view the skeleton of a Pleistocene whale that lived in the Champlain Sea 12,000 years ago.

Cephalopods and other Gastropods. This quarry is an ideal site for the amateur collector like myself; some of the other exposed reef sites are of such major importance to trained paleontologists that attempting to chip out a specimen at those localities is considered akin to looting an archeological dig.

The Vermont Marble Co.'s famous "black marble," filled with white calcite fossil Cephalopods, both coiled and uncoiled, is quarried on the eastern side of Isle la Motte. Highly polished slabs of this ornamental stone are on display in museums around the world, and it is often used for architectural interiors. However, on this island every formation yields fossils, even the Pleistocene gravel deposits. Knowing how to identify the subtleties that differentiate the rocks making up various formations, as well as being familiar with what types of fossils have been discovered in each, are the keys to collecting on Isle La Motte and the rest of the Champlain Valley.

The southwestern portion of Grand Isle has outcrops of the same formations found on Isle La Motte, but here the maze of fault lines and overthrusts have created a bedrock topography that resembles an improperly assembled jigsaw puzzle. The names of these formations provide clues as to where else to find them. Providence Island dolostone makes up most of Providence Island, on the south edge of South Hero. Valcour Island is one place to look for Valcour limestone, and Crown Point, Fort Cassin, Day Point, Cumberland Head, Iberville, Stony Point and Isle La Motte are all place names. The ferry crossing from South Hero, Vermont to Cumberland Head, New York, allows a collector to roam north along the western shoreline through Beekmantown, Chazy, Stony Point and Rouses Point in a search for exposed outcrops of rock, all of which are fossil bearing formations.

Of all the formations found in the Champlain Valley, I've had the most success collecting in the Crown Point and Glens Falls limestones, whose reef structures are so rich in fossil remains that they often form a thick mixture commonly referred to as "hash." The Ordovician mix tures tend to contain:

- Flowerlike crinoids, which are not flowers at all, but animals related to modern starfish, sand dollars and brittle stars. Their columnal stalks are segmented, and often only the Life Saver shaped pieces of these columns are found. *Dendrocrinus alternatus* is found in Glens Falls limestone. Tiny nodules rarely larger than a small pea are cystoids, another member of the phylum Echinodermata.
- Bryozoans, which are referred to as "moss-like animals," but look very much like some species of modern corals. Like corals, the Bryozoans were tiny, soft bodied animals living in colonies, but unlike corals they didn't secrete hard calcium carbonate. Many species are represented in Lake Champlain limestones, with *Diamantites, Prasopora orientalis* and *Eridotrypa* among them.
- Corals, the tiny, soft-bodied animals that are best known for forming colonies, although some species are solitary. Those found in these particular limestones represent the oldest known species of coral.
- Brachiopods, which are clam shells, but are not related to those of modern eras. Numerous species are abundant, including *Diparelasma cassinense, Ateleasma multicostum, Finkelnburgia parva, Rostricellula major, Hesperorthis tricenaria* and many others.
- Gastropods, snails of which many types can be found in these limestones. *Maclurites affinis* and *Maclurites magnus* are two of the most sought after specimens. But *Hormotoma gracilis, Loxoplocus* and *Lophospira* specimens, as beautiful as they are, look so much like modern relatives that they are often ignored.
- Cephalopods, which have chambered shells and are found both coiled and uncoiled. At first glance, many of the species of *Maclurites* are mistaken for nautiloids. Several species are represented, many of them quite large.

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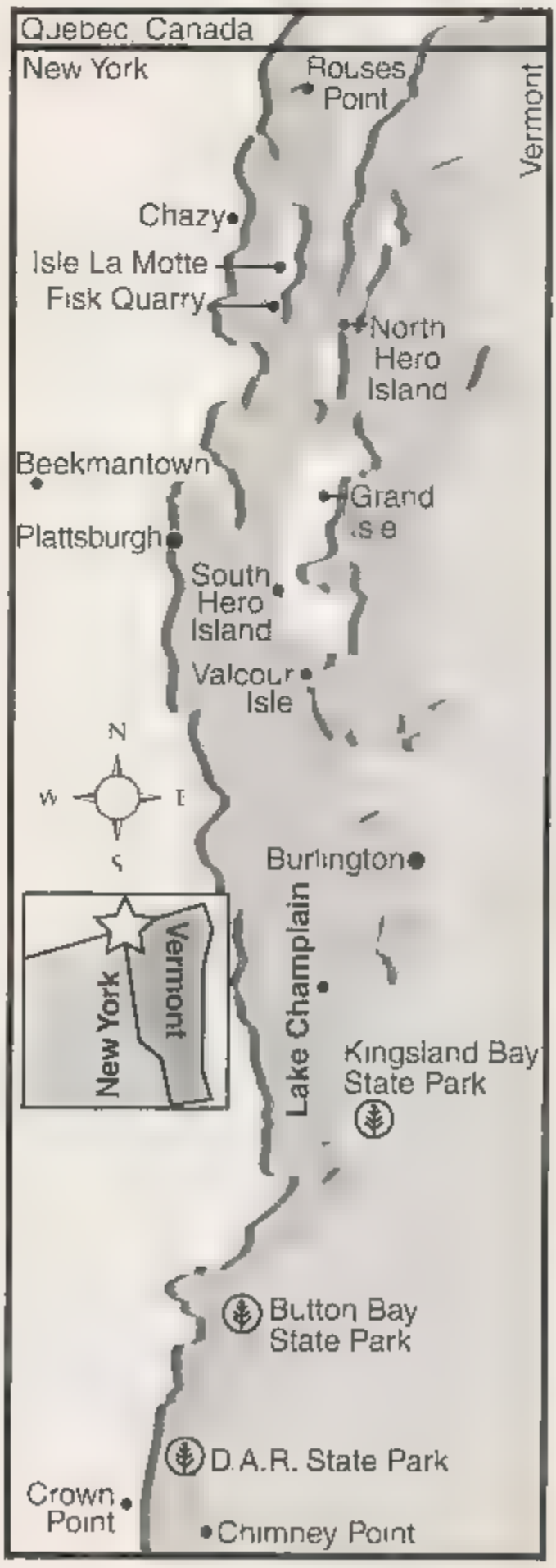
Lake Champlain/ *from page 75*

• Trilobites, which were Anthropods, not crustaceans, and lived from about 550 to 325 million years ago. The horseshoe crab is their closest living relative. *Glaphurus pustulatus*, *Cybeloides primus*, *Caliops callicephalus*, *Cryptolithus tesselatus*, *Flexicalymene senaria*, *Isotelus gigas* and *Triarthrus beckii* are some of the species of trilobites found in the Champlain Valley. Since trilobites shed their exoskeletons as they grew, fragments are especially plentiful in fossil hash.

• Porifera, also known as sponges, which are well represented in Crown Point and Glens Falls limestones. *Stromatocerium*, *Secospongia* and *Zittelella varians* are three of several species found.

Examining fossil hash tends to be a time-consuming endeavor. Out in the field, I've spent hours at a time examining a single surface, while the specimens I bring home receive days of painstaking attention in the process of inspection, preparing and cataloging. I'm limited to the use of magnifying loupes when working on my collection, but micropaleontology, requiring powerful microscopes, has become a major field of study, and the fossil deposits of the Champlain Valley have proven to be especially productive. It makes sense. These fossils represent a densely populated ecosystem, and the concept of biological food chains was as valid 400 million years ago as it is today, all of these Anthropods, Gastropods, Cephalopods, Porifera, Bryozoans, Echinodermata and corals were eating something smaller than themselves!

Micropaleontology may be the cutting edge of study in the field, but I still have work to do before I can turn my attention to it. My collection lacks an *Isotelus gigas* and an *Elliplocephalus thompsoni*, and I have yet to find a complete *Cryptolithus tesselatus*. Actually, there's quite a lot that's not in my collection, so I guess it's time to pack my gear and make another trip to the lake where life began.



Fossils on Display

Fossils from Lake Champlain can be viewed in the collections of Vermont's Middlebury College, the Fairbanks Museum in St. Johnsbury, or more appropriately, the Perkins Museum of Geology at the University of Vermont.

The Perkins Museum of Geology is located just behind the famous Ira Allen Chapel on the main campus of the university. A sign near the entrance invites visitors to turn on the lights to view the exhibits, and turn them off when leaving.

The fossilized skeleton of the Charlotte Whale, an extinct species that lived in the Champlain Sea 10,000 to 12,000 years ago, is prominently displayed inside the entrance. The fossil was discovered in 1849. In display cases behind the skeleton are selected specimens from the Vermont State Fossil Collection, including excellent examples of trilobites, particularly an *Elliplocephalus thompsoni* and an *Isotelus gigas*. Polished specimens of the famous Black Marble from Isle La Motte show the white fossil remains of Cephalopods. Fossils from other localities, mineral specimens and educational displays make this small museum a treat to visit.

The museum is open 9-5, Monday through Friday, or visit online anytime at http://geology.uvm.edu/museumww/intropage.htm. For more information, call (802) 656-8694.

The MINERALS

This City's Rapid Growth Is Exposing New Finds

by William L. Rader

The Cretaceous marine sediments upon which much of the city of Austin, Texas, is being built are well known for the abundance of fossils they contain. Area mineral collectors are also aware of the fact that this same rock has acted as host to a suite of minerals that forms in sedimentary rock including aragonite, calcite, celestite, gypsum, marcasite, pyrite, strontianite and barite. The nice-shaped prismatic celestite crystals for which central Texas is known are the greatest prizes to be found in area rocks, and occur at several localities within the city limits.

In the paragraphs that follow, I will briefly describe some of the mineral collecting experiences that I have had both as a visitor to and a resident of Austin between 1956 and 2001. The localities that I describe herein should not be construed as a complete list of collecting sites that exist within the city, nor are all of them still accessible. They are simply those localities that I felt were most worthy of mention because of the interesting mineralization that occurred at each.

BULL CREEK CELESTITE

As I make my way along the hiking trail beside Bull Creek, evidence of recent flooding is plainly visible. Shredded plastic bags and cloth rags wave from tree branches that are fully the height of a man and higher above the present level of the creek. The tires of a vehicle have cut deep ruts into the earth of a primitive track that crosses over the creek. One of these ruts is filled with water. I stare disbelievingly at two panfish that have been trapped in this temporary pool and are attempting to extract what oxygen they can from their limited surroundings.

I progress slowly downstream along the bank of the creek, dwarfed by the trees. They in turn are overshadowed by the massive limestone wall that rises above them. At times, I bog down in the moist piles of dead leaves that litter the way. At other times, I am forced to climb over or detour around enormous slabs of limestone that have fallen from the wall above and come to rest on the sloping bank of the creek. Though the going is slow, I am nevertheless approaching the object of my quest.

Several weeks prior to my Christmas vacation in Austin, I had contacted Art Smith about potential mineral collecting localities in central Texas. Art is a geologist in

A cavity full of 2-inch calcite scalenohedra from a construction site in north Austin. (Photos by the author)

# of Austin, Texas

Hobbyists who, unlike the majority of his colleagues in the rock business, has a keen interest in regional mineralogy. If his name seems familiar, it is no doubt due to the many articles he has authored, particularly on the minerals of Texas and Arkansas. Art's book *Collecting Arkansas Minerals* (L. R. Ream Publishing, 1996) is an indispensable guide to collecting localities in the Diamond State, and is in fact one of only two published reference works on Arkansas minerals. For more information on this volume, contact Lanny Ream at 208 [illegible]-2448, e-mail lanny@minera.news.com.

One of the localities Art had suggested was Bull Creek in northwest Austin. He told me that well-crystallized specimens of celestite could be found in vugs in the massive limestone of the Lower Cretaceous Glen Rose Formation through which the creek has cut. He also informed me that some of this material was the bladed, pale-blue celestite prismatic crystals having a bluish tinge at the termination for which the Glen Rose Formation is known. As Bull Creek was only about a mile from my father's home, I decided that this would be one locality I would actively explore during my stay in Austin.

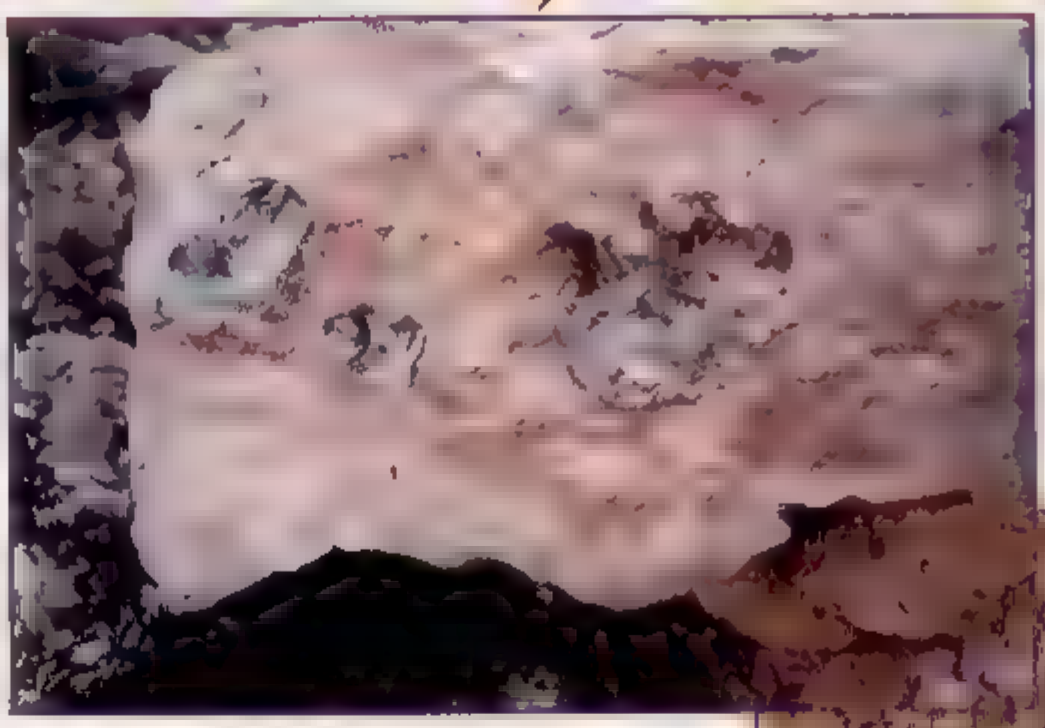
Limestone outcrops along Bull Creek are visible in several places from Highway 360, a four-lane road that loops around the western portion of the city. One day during my visit, as we drove past one particularly high section of limestone wall, I noticed that a portion of the rock in the wall was a cream color. This indicated to me that the rock was fresh, as massive Glen Rose limestone rapidly weathers to an unsightly dark gray or black after being exposed to the elements. Perhaps the rock that had given way and fallen to the base of the wall was mineralized. It was certainly worth finding out.

I progressed along the bank of the creek to a point directly beneath the exposure of fresh rock I had seen from the highway. I stepped out of the darkness created by the dense tangling of tree branches and into sunlight. There, at my feet, was a small block of cream-colored limestone. Upon closer inspection, I found that the block contained a small vug in which light blue celestine crystals had formed. I quickly made my way to a larger, neighboring block of identical rock and found that it, too, contained vugs with celestite crystals.

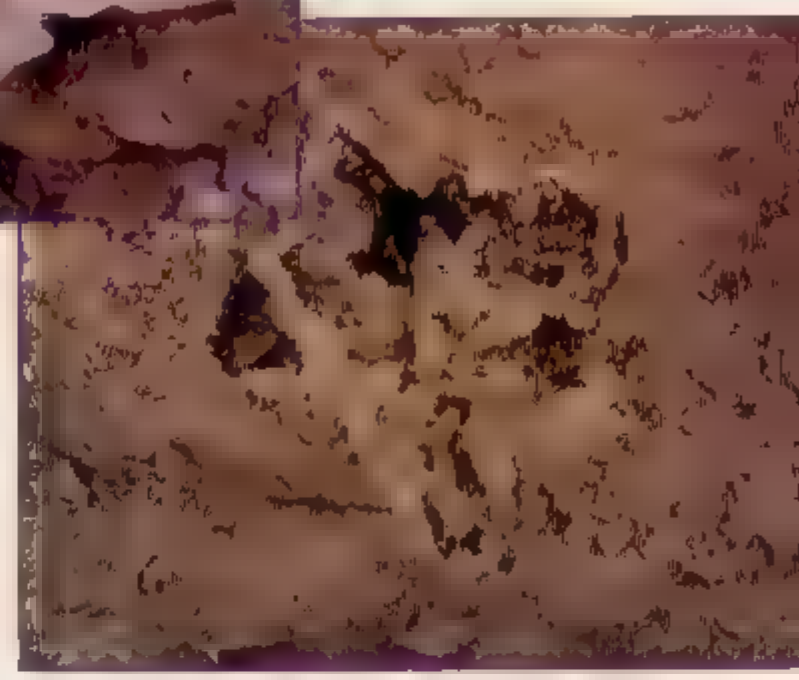
I was standing in an opening that had been cleared of underbrush by rock that had recently fallen from the wall above. Around me rested the tumbled remains of cream- to gray-colored blocks and slabs of limestone that ranged in weight from hundreds to thousands of pounds. The majority of the fallen rocks contained one or more mineralized vugs on their surfaces. These vugs are, for the most part, spherical in shape and are a fraction of an inch to about 3 inches in diameter. Most, but not all, vugs were mineralized. Those that contained celestite usually contained a tan clay mineral that had formed on their walls. Celestite crystals had grown upon or within the clay, and at times intergrown masses of crystals, together with a coherent clay rind, could be removed intact from the walls of vugs.

These celestite crystals range in size from micros to 2 inch doubly terminated crystals. The crystals are elongated prisms that may taper toward both ends. Terminations are flat or tapered to something of a point. Prism faces are sometimes lustrous but many are etched. Colors generally vary from clear to light blue. Dark blue crystals were far from rare, though. Some of these crystals are tinged dark blue throughout and others solely at the termination. Crystals formed singly, often growing roughly perpendicular to vug walls. In some cases, one large crystal acted as a nucleus from which other, smaller crystals grew. Intergrown masses of crystals are also quite common.

I concentrated on collecting celestite crystal vugs that appeared to contain few or no imperfect crystals. There was such an abundance of material that I felt my time was best spent either cobbling down small limestone blocks to transportable specimens or diagonally undercutting vugs that were found at or near the edges of slabs.



Multiple vugs containing celestite crystals (left) were found in the limestone at Bull Creek. This calcite-lined vug (below) was exposed during road-building activities in the City Park area.



I had been dropped off at Bull Creek with a hammer, a chisel, a small cardboard box, a heavy paper shopping bag and toilet paper for wrapping delicate specimens. I left the clearing with much more material than I could carry with two hands. I made two subsequent trips back to the locality, and I was certainly better prepared for collecting than on day one. During the three days I spent there, I filled two large, plastic storage containers with specimens. The showiest specimen was a clay-lined vug, approximately 3 inches in diameter, that contained numerous micro- to macrocrystals. The vug had broken in half when I attempted to remove it from a limestone block. Half of the vug remains in my collection, the other half was deposited in the reference collection of the Mineral Science Section of the Los Angeles County Museum of Natural History.

Two years later I returned to the celestite locality with a local collector. As he extracted a number of nice vugs containing celestite crystals from a massive slab just above creek level, I broke apart a block of light gray limestone upslope from him. I discovered several vugs in which a number of light- to dark-blue doubly terminated crystals lay loose. Again, the largest of these crystals was approximately 2 inches from tip to tip. It was tinged dark blue at both terminations.

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Minerals of Texas/ *from page 81*

I haven't returned to the celestite locality since 1998, though I am certain more material can be found in the rock there. I have heard that this site may be closed to collecting, though I cannot substantiate this claim. Still, it would probably behoove a collector to ascertain the current collecting status at this locality before breaking any rock.

CONVICT HILL STRONTIANITE

A wall of massive cream-colored Glen Rose limestone that has weathered to gray in spots rises in front of me. From behind me, the sounds of stainless-steel utensils striking German nickel and plastic dishes tapping together pass through screen doors at the rear entrances of a series of fast-food restaurants. The smell of fried food mixes with the malodorous scent of rotting vegetables from a nearby dumpster. From time to time, an employee opens a door and steps out for several minutes, adding cigarette smoke to the mix. All in all, the ambiance makes for a quite unusual mineral-collecting locality.

I am facing a low wall of the long-defunct Convict Quarry (so named because it was once worked by convict labor) in the Oak Hill section of southwest Austin. The collecting site is located behind an L-shaped strip mall that is situated on the southwest corner of the intersection of state Highway 71/U.S. Highway 290 and William Cannon Drive West. This is another locality Art recommended, and the mineral I am seeking is strontianite.

As I move slowly along the rock face, I note that strontianite occurs abundantly, lining fractures in several rock layers that are located about a third of the way up the quarry wall. It consists of aggregations of numerous minute, transparent needles that have grown outward from massive white material. While fresh strontianite is snow-white, it weathers to a less aesthetic gray.

After I have moved approximately halfway across the wall, I observe an interesting object protruding from the limestone at about eye level. Taking my rock pick, I delicately free the object. It proves to be a strontianite nodule approximately 4 inches in diameter that is slightly flattened in the vertical plane. Within the nodule is a network of voids that are lined with the same transparent needles that characterize strontianite mineralization at this locality. The nodule will be the prize of the day.

Push the clock forward to the first year of the new millennium. Winter rains have caused small-scale rockfalls to occur at various points along the wall of the quarry. As I break up the material that lies at the foot of the wall, I expose a second nodule—a beautiful specimen that measures about 2½ inches in diameter. I also discover a handful of small vugs, most less than an inch in diameter, that contain lustrous modified calcite scalenohedra, 1 to 2 mm in size, that have formed individually or in clusters on clay. I am able to localize the calcite mineralization on the quarry wall, and I add another half-dozen or so mineralized vugs to my take. I find several vugs in which strontianite has mineralized together with calcite.

Since the quarry wall appears to be part of a commercial property, I have done very little in the way of moving rock in search of further strontianite and calcite mineralization. I have simply watched nature take its course, waiting for heavy rainfall to undermine the integrity of the fractured limestone and then breaking apart the rockfall when it is still fresh on the ground. I have no doubt that the strontianite-bearing layers are being exposed elsewhere in the Austin area by construction and road-building activity. However, I have done little in the way of exploration for potential collecting localities.

PFLUGERVILLE PYRITE

A thunderstorm is approaching ominously and is now only a mile or so away from my present position. The wind the storm generates blows sheets of fine, powdery chalk dust across a dead zone of rock rubble. I press on toward my car in anticipation of the coming deluge, hastily scanning the barren rock for any sign of the marine fossils I have come in search of.

It is late spring in 2000, and I am now living in Austin. Much of my free time is spent exploring a series of construction sites that are being excavated southwest of Pflugerville in extreme northern Austin. Broken rock of the Jonah Formation of the Cretaceous Austin Group covers what must be the better portion of a square mile. The rock is a white to light bluish-gray chalk that breaks down into a fine powder, which spreads like a blanket over everything in its path.

Flashes of silver or of gold occasionally catch my eye as I proceed across these deserts of chalk. Both colors indicate the presence of pyrite (FeS_2), which I am finding as disseminated grains in the rock, as clusters, or aggregations, of discrete intergrown crystals, and as nodules. In earlier publications, FeS_2 nodules in the Jonah Formation were referred to as being composed of the mineral species pyrite. The more recent convention seems to be to call them "marcasite" because of the rapidity with which they weather and disintegrate. To date, I have had none of my specimens tested in order to ascertain species. However, since the crystals on the outside of nodules are octahedrons, cubes and combinations of the two forms, and do not appear to be pseudomorphs, I feel safe in referring to this material as pyrite.

While I sometimes find crystal clusters loose on the ground, I must remove most of them from the rock in which they are enclosed. Though many of these clusters have formed in white-colored chalk, the bluish-gray rock provides the freshest specimens. The same holds true for nodules. Crystal clusters are generally small, and infrequently exceed an inch or so in size. Individual crystals can be ⅛ inch on a side, but are usually less. The crystal faces are smooth, stepped, notched or striated, with the crystals themselves being cubes, partial cubes or distorted cubes.

I find the nodules in the Jonah Formation to be aesthetically pleasing. Though my main quarry is fossils, I am never able to pass up an opportunity to collect a nice nodule. In shape, the nodules are spherical, oval or roughly dumbbell shaped. The last type attains the greatest size, up to 5 inches in maximum dimension. The diameters of spherical or oval nodules are somewhat less, and are on average about 2 to 2½ inches. All nodules are composed of intergrown micro- to small macrocrystals that have grown on the exteriors of iron disulfide cores. The crystals are cubes, octahedrons or cubo-octahedrons. Mineralization appears to be localized throughout the rock I am prospecting. Where I discover one nodule, I usually find others in close proximity.

Fresh pyrite is silver or brass-yellow to gold in hue, and tarnishes to a brassy color. The crystal faces of fresh specimens are resplendent. In rare instances, slight weathering produces a multicolored, iridescent tarnish that occurs in color bands on the exteriors of nodules.

The majority of the pyrite specimens I encounter during my collecting trips are weathered. Nodules seem to rapidly decompose or else become coated with "rinds" of limonite. Still, I have been able to assemble a collection of about five dozen exemplary nodules and an equal number of crystal clusters during the time that I have been collecting these construction sites.

CALCITE FROM NEW CONSTRUCTION SITES

A debris pile that is composed of rock, soil and tree roots rises above a recently excavated landscape. The boulders within the pile are badly weathered and have been stained rather unappealing shades of deep red, brown and black by iron oxide. The soil, too, is an unaesthetic red-brown color. Amid the debris, however, there are signs of hope for the future. Here and there, cleavages of calcite can be found in cavities within the rock. Some of the calcite is relatively fresh.

The debris pile sits on a construction site that is located along the access road just west of Highway 1 (Mo. Pac. Expressway) between York and Tudor boulevards. Excavation for an office building and an adjoining parking structure has just begun. It is the summer of 2000.

Weathered rock that is easy for construc-

Highly fractured strontianite-bearing layers are located a third of the way up this limestone wall at Convict Quarry in southwest Austin.

tion equipment to scrape off the surface soon gives way to a resistant tan-colored limestone that is honeycombed with cavities, many of which snake their way through the rock. Heavy equipment is brought in to remove this tenacious limestone.

It soon becomes apparent that this fresh rock is heavily mineralized with calcium carbonate. Many of the mineralized cavities are filled with massive calcite or lined with granular calcite. As work progresses, though, cavities containing crystalline calcite become more common. The crystals are poorly formed to sharp scalenohedra, which are white and at times stained red by iron oxide. Scalenohedra range in size from a fraction of an inch to 2½ inches for the largest crystals. Cavities are several inches to as much as a foot across.

The high point of collecting comes on a Friday evening several weeks into excavation. The day's work has uncovered several large, well-mineralized cavities. The best specimens consist of a pair of boulders, each containing a large crystal-lined cavity and two to three smaller cavities. The two boulders are at the upper limit of my strength to carry, but with determination I am able to transport them successfully across the site to my car. Four smaller specimens round out my collecting for the evening.

Unfortunately, this would be one of my last successful forays into the excavation. As more construction materials are brought into the site, the gate barring entry begins to be locked by the construction crew at the end of the work day. By this time, however, I have been able to obtain some pretty sensational examples of what I consider to be the nicest calcite I have seen to date in the Austin area.

As I am writing this article, nice calcite-lined vugs are being exposed by road-building activity in a newly developed subdivision that is located in west Austin. The site is on the east side of Bridge Point Parkway near City Park Road. Numerous vugs, some sizable, in cream- and gray-colored limestone are lined with druses of clear to amber scalenohedra. These scalenohedra are generally small, rarely exceeding ½ inch in size. Vugs that are lined with first-generation calcite crystals on which a "frosting" of white, noncrystalline, second-generation calcite has formed make the most aesthetic specimens. These are easily collected in rock that has been piled up at the entrance to the subdivision.

Rapid growth in Austin is creating the need for increased commercial and residential development, along with the construction of new roads and highways. The excavation of fresh rock continually enhances the possibility that more nice mineral specimens will be exposed to collectors in the days to come.

At present, Austin is a rapidly expanding city, due to an ever-increasing influx of people. Commercial and residential development can be seen practically everywhere. With this development has come the necessity of constructing new streets and highways, as well as widening those thoroughfares that have proven too narrow to accommodate greater road traffic. These should prove to be heady days for local mineral collectors, for as more and more weathered surface rock is stripped away to expose fresh marine sediments, the chances of collecting interesting specimens of sedimentary minerals can only increase. No doubt reports of nice mineralization will continue to surface throughout Austin's boom days.

On the Rocks

by Bob Jones

A Peek at the Four Peaks Amethyst Mine

Four Peaks amethyst is purported to carry the elusive c-face, a flattened crystal termination. (Evan Jones Collection/Photos by the author)

I've always loved amethyst. It comes in so many forms and is relatively inexpensive. It occurs in superb crystal groups. When cut, it is a stunning royal violet color fit for any king or queen. It is found lining the interior of rounded "coconut" geodes from Mexico, and it comes from South America as brilliant, pointed linings of huge tubular and geodelike forms. In fact, some of those Rio Grande do Sul occurrences in basalt are so large that people can walk right into the open cavities as if walking in a cave lined with amethyst. That would be a wonderful experience. So it's no wonder amethyst is one of the more popular forms of quartz available. Used as a gem, as an office decoration, as a knick-knack in your home, as an object of wonder in a geode, or as a colorful part of a mineral collection, amethyst has a long history of adding beauty to our world.

Superb gem amethyst is eagerly sought by specimen hunters and gemologists. Though found in a great number of places as a fine mineral, there are relatively few sources of the finest gem amethyst. The best gem amethyst shows a rich violet color with red highlights. The fine material that comes from Las Vigas, Mexico, superb as it is, does not measure up to the best amethyst. Though it is a lovely violet color, it lacks the flash of rich red that would put it in the top gem category. The same is true of the amethyst from those huge crystal-lined cavities in Brazil. Again, excellent violet color is there, but that special reddish hue is lacking.

The best gem amethyst only comes from a few places. The best known sources are the Ural Mountains in Russia, Korea, and a rugged mountain in Arizona called Four Peaks, a major formation in the Mazatzal Range. These are not the only sources, but these three localities have been the major sources and are considered by most to be the standard for the best amethyst gem material.

The Ural Mountain and Korean sources are not actively producing a lot of gem rough these days. Sure, there is a lot of superb amethyst coming out of Russia now, but its birthplace is not the Ural Mountains; it's a gem-growing laboratory. Huge quantities of the synthetic material are being offered for sale these days.

This leaves the amethyst mine on Four Peaks Mountain, east of Phoenix, Arizona, as one working source, and when the guys who market the cut stones asked if I'd like to hike up to the mine, I jumped at the chance. The timing seemed perfect. It was early spring in the desert. The Palo Verde trees were just beginning to blossom. The California poppies were already a riot of orange, and most of the desert cacti were budding or blooming. We set Sunday, Apr. 22, as the day to hike to the mine. Actually, it is a hike *up* to the mine, since the mountain is just under 8,000 feet high and the mine is just under 7,000 feet, a couple thousand feet above where we parked the vehicle.

Left: The Four Peaks Amethyst Mine, nestled below a rugged cliff, produces some of the finest amethyst gems in the world. Right: Rock & Gem's *senior editor prepares to hike to the Four Peaks mine with miner Ed Davis.*

We rendezvoused at the appointed hour, which meant we had to get up at 4:30 a.m. Imagine our surprise when dawn broke to reveal four rugged mountain peaks blanketed in snow! During the night, a blustery storm had blown across the desert and dusted everything above 5,000 feet.

Undaunted, we loaded our gear and drove to the trailhead leading to the mine. We parked the vehicles, threw a couple of snowballs, and headed south and up. The trail, called the Lone Pine Trail, starts well north of the four dominant peaks that form Four Peaks Mountain. It winds its way around two hills to "The Saddle," which is the actual take-off point for traversing the western faces of all four rugged peaks to get to the mine. The Lone Pine Trail is not considered too difficult, but like any mountain trail it seems all uphill—even when you are returning to the vehicles!

The problem we encountered was twofold. First, there was the snow—nice, heavy, wet stuff, which instantly packed down to form a slippery surface. Then there were the deadfalls, trees of all sizes and shapes that had been blown down by the 50-plus mph winds of the night before. Still, we managed to struggle up trail to the Saddle.

Our final trek took us across the faces of those rugged peaks to reach the mine. Unfortunately for us, the mine is located some four and a half miles from where we started, and a very tough two and half miles from the Saddle. Still, under normal circumstances it would have been a reasonably enjoyable hike. But with 4 to 6 inches of snow, it was anything but normal.

The first thing was to find the trail and keep on it. Second, and very scary, was the fact that some of the trail was only 6 inches wide on a 60-degree slope. We had to work our way around cliff faces and rock falls on the snow-packed trail, while trying to avoid a rapid descent into the canyon below!

Two and a half hours later, we climbed the last rock fall and reached a small blasted-out shelf that was the working area outside the mine tunnel. There was plenty of room for our group to relax, eat a bite, and scan the ground for shards of lovely amethyst. They were all over where the snow had melted to expose them. Since the tunnel itself is new and relatively small, we were only able to crawl in two at a time.

The host rock is metamorphic, and was probably under water at one time, since we saw wave-generated ripples preserved as metamorphic rock. The amethyst is found locked in clay along a huge quartz vein system. The crystals here can reach 7 or more inches in length, with the better gem material close to the termination.

Once inside the mine, we could see the crystalline quartz amethyst. It seemed to be everywhere. The seams occasionally open up so that sharp crystal points protrude. Seeing gem crystals in place is always an exciting event for any collector.

Since this is a working mine, we respected the owners and did not attempt to collect. It was enough to see gems in the rough—in this case, really rough, thanks to that slippery trail. The amethyst is a superb color, ranking with the best from anywhere. At the present time, much of the material coming out of the mine is fairly small, so gems exceeding 5 carats are uncommon, though in the early days faceted gems approaching 100 carats were possible. Large gem crystals will undoubtedly be mined again as this new area is developed.

For the crystal collector, the Four Peaks Amethyst Mine holds a special place because of something called a "e-face," a very rare crystal face found on Four Peaks quartzes.

A quartz crystal has six flat prism faces, topped by sloping termination faces, ending in a sharp point. Each crystal face is given a letter for ease of identification. The sloping faces are called "r" and "z" faces. The side faces, called prism faces, are labeled "m." There are other very tiny faces, which are given other letter names. Such is the language of the crystallographer.

Among the smaller and often rare faces on quartz is the e-face. It ranks among the rarest of the quartz crystal faces and is eagerly sought by students of this mineral. Fortunately, the Four Peaks Mine is rich in e-face amethyst crystals.

The e-face gets its name for its position on a crystal. It shows up as a tiny, flat face on the very top of the crystal termination, looking as if someone had ground off the point. It's called the e-face because running down the center of every quartz crystal is its long axis, the c-axis. If the axis were actually visible, it would exit at that very top point, right where that tiny, terminal e-face is found.

So, the scary hike, the enervating albeit exhausting climb, the sloppy slush—all were worth it to see the source of both superb amethyst gem rough and a crystallographic rarity, e-face quartz crystals.